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MEMO

To:
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Bill Bath, Lockheed Martin
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From:
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Date:
April 10, 2012

ARCADIS Project No.:
GP000677.0015.FE000

Subject:
Establishment of Upper Prediction Limits for Detecting a Statistically Significant Increase in Groundwater Concentrations
Lockheed Martin Hazardous Waste Post-Closure Landfill
The Dalles, Oregon
ORD 052 221 025

This memo presents a summary of the 99% Upper Prediction Limits (UPL99) to be used in detection monitoring as requested by the Oregon Department of Environmental Quality (ODEQ) to support permit renewal at The Dalles. The program described below includes key components from the United States Environmental Protection Agency (USEPA) 2009 Unified Guidance (UG) and consists of the following elements:

- Three constituents (cyanide WAD, fluoride, and sulfate) in six monitoring wells (MW-17S, MW-22S, MW-23S, MW-35S, MW-36S, and MW-37S).
- A 1-of-2 retesting schedule which means that if 1-of-2 resamples following an exceedance is within bounds, the well is considered to "pass" the test with no statistically significant increase (SSI).
- A *k*-factor of 4 was used such that a well and constituent is expected to be below the UPL with 99% confidence for the next four samples.
- MW-5S is an upgradient well that will be used to help detect alternate (upgradient) source areas should an onsite exceedance occur.
- If an SSI is detected in future monitoring, it does not imply or prove that contaminated groundwater at the facility is the cause of the increase. Refer to Chapter 4 of the UG (USEPA 2009) for factors to consider before an SSI can be considered a site-related release.

Supporting tables, figures, and raw data used in the evaluation are included as attachments to this memo.

Background

In many groundwater monitoring programs it is desirable to know with some statistical probability the expected concentration for the next one or more samples (e.g., four future annual sampling events). Prediction intervals are used to estimate the (1-α) probability that the next few sample value(s) or sample statistic(s) will be contained with the interval. The boundaries of the prediction intervals are referred to as Lower Prediction Limits (LPLs) and Upper Prediction Limits (UPLs). When constructed properly, these values can help to identify a SSI previously defined.

The purpose of this analysis is to develop an intrawell statistic that can be used to detect an SSI for several indicator constituents monitored as part of the groundwater monitoring at the Lockheed Martin Hazardous Waste Resource Conservation and Recovery Act (RCRA) landfill located in The Dalles, Oregon. If an SSI is detected in future monitoring, it does not imply or prove that contaminated groundwater at the facility is the cause of the increase or that the landfill is failing or has failed. Refer to Chapter 4 of the UG (USEPA 2009) for factors to evaluate before an SSI can be considered a site-related release.

This memo provides an overview of the following analysis steps:

1. Overview of Background Threshold Values (BTVs) and their use
2. Trend analysis to identify any increasing trends that could result in potential UPL exceedances
3. Goodness-of-fit (GOF) testing to support selection of parametric or nonparametric UPL methods
4. Dataset conditioning including the selection of an appropriate baseline period, estimation of non-detects using Kaplan-Meier (KM) methods, and treatment of field duplicates

Statistical Methods

Background Threshold Values (UTLs vs UPLs)

Background Threshold Values BTVs are routinely used to determine if a sample or set of potentially site impacted samples is elevated compared to background. The goal is to test compliance samples against a BTV that represents background conditions now and those likely to occur in the future. BTVs for groundwater monitoring and compliance assessment are often represented by a one-sided upper tolerance limit (UTL) or an upper prediction limit (UPL) for the background population. BTVs can be <u>inter</u>well or <u>intra</u>wall statistics.

Interwell BTVs should be used to compare between upgradient and potential impacted wells when there is no evidence of spatial variability at the site. <u>The UTL is an appropriate statistic when the intent is to compare data from unimpacted wells with data from potentially impacted wells</u> (Section 5 of USEPA [2009]). Tolerance limits provide an interval within which at least a certain proportion of the population lies, with a specified probability that the stated interval does indeed "contain" that proportion of the population

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Interwell BTVs should be used to compare between upgradient and potential impacted wells when there is no evidence of spatial variability at the site. <u>The UTL is an appropriate statistic when the intent is to compare data from unimpacted wells with data from potentially impacted wells</u> (Section 5 of USEPA [2009]). Tolerance limits provide an interval within which at least a certain proportion of the population lies, with a specified probability that the stated interval does indeed "contain" that proportion of the population

(USEPA 2006; 2009a). A 95/95 UTL indicates that 95% of the population is contained within the limit with 95% confidence. A minimum of 8 observations and 5 detections are recommended in the background dataset to calculate a 95/95 UTL (USEPA 2009). If sample sizes are insufficient, the BTV may be approximated by the maximum detected concentration in the background dataset or be based on the Double Quantification Rule as described later.

Intrawell BTVs should be used when there is evidence of spatial variability at the site (USEPA 2009). UPLs are used to represent the BTV when the goal is to assess whether the next sample or set of samples is above or below the BTV. Upper prediction limits represent a value such that the next one or more (*k*) samples will be less than the UPL at a specified level of confidence (e.g., 95 or 99%). Section 5 *(page 6-43)* of USEPA (2009) covers detection monitoring program design and states "*Prediction limits are exceptionally versatile, since they can be designed to accommodate a wide variety of potential site monitoring conditions. They have been extensively researched, and provide a straightforward interpretation of the test results... Prediction limits can be used both for **interwell** and **intrawell** testing."* UPLs are preferable over control charts since they do not require updating after every sample event. In fact, the UG suggests that intrawell background values not be updated until at least 4 to 8 new compliance observations have been collected. Updates are also predicated on there being no statistically significant increase (SSI) for the well and constituent.

There are several considerations when computing UPLs. Prediction intervals can be parametric (e.g., having a normal distribution or can be transformed to normality) or non-parametric. Data should be tested using common GOF tests and/or quantile plots as described below. Although UPLs can be generated on as few as three samples, the prediction intervals based on such small sample sizes can be unacceptably large providing little statistical power to detect an SSI. Therefore, a minimum of eight samples is preferable for constructing parametric prediction intervals (USEPA 2009). Samples should be independent and not demonstrate significant temporal trends or seasonal variation. For left-censored datasets, non-detects can be estimated using KM methods to generate a non-parametric UPL. In addition, care must be taken when calculating UPLs in order to limit the site-wide false positive rate (SWFPR) while also providing adequate statistical power to detect an SSI. Finally, when using UPLs to detect an SSI, an appropriate retesting strategy must be used so that an exceedance can either be confirmed or discounted based on a set number of consecutive samples.

For The Dalles, a UPL99 ($\alpha = 0.01$) was calculated to provide sufficient power to detect a statistically significant increase while limiting an SWFPR to less than 10%. The UPL95 ($\alpha = 0.05$) was also computed and displayed on the time-series plots to illustrate the relatively small difference between the UPL95 and UPL99; however, the UPL99 results in a SWFPR well below 10% whereas the UPL95 results in an SWFPR slightly exceeding 10% when considering three constituents, 6 wells, $k = 4$, and a 1-of-2 retesting schedule. Power calculations were performed in Sanitas statistical analysis software (Sanitas Technologies 2010). Due to software licensing restrictions and the absence of a license for The Dalles, graphical results cannot be included in this report. However, Sanitas is freely available to regulatory agencies and can be used if desired to confirm the power and SWFPR of the detection monitoring program (Rayner, pers., comm. 2011).

Parametric prediction limits were calculated using one of the following equations depending on the data distribution:

- Normal Upper Prediction Limit

$$UPL = \bar{x} + t_{((1-\propto/k),(n-1))} \times s \times \sqrt{(1+1/n)} \qquad \text{Equation 1.0}$$

- Lognormal Upper Prediction Limit

$$UPL = \exp\left(\bar{y} + t_{((1-\propto/k),(n-1))} \times s_y \times \sqrt{(1+1/n)}\right) \qquad \text{Equation 2.0}$$

- Gamma Upper Prediction Limit (Wilson-Hilferty)

$$UPL = \max\left(0, \left(\bar{y} + t_{((1-\propto/k),(n-1))} \times s_y \times \sqrt{1+(1 \div n)}\right)^3\right) \qquad \text{Equation 3.0}$$

where $\bar{x}$ is the sample mean, $t_{((1-\propto),(n-1))}$ is the critical value from the Student's t-distribution with (n-1) degrees of freedom, *s* is the background standard deviation, *n* is the number of background samples, and *k* is a multiplier depending on the future number of samples for comparison. Finally, $\bar{y}$ and s_y are the sample mean and the standard deviation based on the transformed data. For the Wilson-Hilferty approximation, the transformation (Y) is equal to $X^{1/3}$ and follows an approximate normal distribution.

If the data do not follow a normal, lognormal, or gamma distribution, then the use of a nonparametric UPL based on the m^{th} order statistic can be calculated based on Equation 4.0. The equation is also provided with more detail in the ProUCL v4.1 technical guide (USEPA 2010; Equation 3-16). For small datasets the nonparametric UPL95 or UPL99 value will be equal to or very close to the maximum value.

- Nonparametric Upper Prediction Limit

$$UPL = X_{(m)}, where\ m = (n+1) \times (1-\propto) \qquad \text{Equation 4.0}$$

Double Quantification Rule (DQR)

In some cases, the entire dataset is less than the reporting limit (RL) (e.g., 100% nondetect) and a statistically based BTV is not appropriate. In those cases the UG (USEPA 2009) recommends using the

DQR. Specifically, the UG indicates that any constituents that are "never-detected" be evaluated using this quasi-statistical rule:

> *"A confirmed exceedance is registered if any well-constituent pair in the '100% non-detect' group exhibits quantified measurements (i.e., at or above the reporting limit [RL]) in two consecutive sample and resample events."*

Trend Analysis

Trend plots show the concentrations over time within a well or within all wells grouped together. The purpose for evaluating trends when reporting UPLs is to be sure that a trend is not masking an SSI. When a background data set that is being analyzed and a temporal estimator such as an UPL is used, there is always the chance that the statistical test is passed (e.g., < UPL), but is masking a true increase as the background values rise with a trend, sometimes referred to as "UPL creep." Decreasing trends pose no such danger except when a lower boundary on the data is of interest, which is not the objective of this analysis.

Trend plots can reveal periodic fluctuations (e.g., seasonality) or an overall trend (increasing or decreasing) in the data. Three statistical tests may be applied: Mann-Kendall (MK) test, Sen's slope estimator, and Seasonal Kendall (SK) test. The MK and Sen's slope tests are implemented in Microsoft Access and Excel following USEPA (2009) guidance. The SK test can be implemented with SYSTAT (SYSTAT Software, Inc.) or the U.S. Geological Survey (USGS) computer program called Estimate Trend (ESTREND), which is available from http://pubs.usgs.gov/sir/2005/5275/.

The MK trend test is a non-parametric test for linear trend. The test has the flexibility to be modified to account for multiple observations per time period, multiple sampling locations, and seasonality (USEPA 2006, 2009). The statistics for the MK test were implemented in Microsoft Excel following USEPA (2009) guidance. The MK test has the flexibility to accommodate any particular distribution form and is relatively insensitive to outliers and nondetects (values less than RLs). The test compares each data point to every successive measurement and determines if the change is positive or negative (the magnitude of change, or slope, is not considered). Each discordant pair is given a score of -1 and concordant pairs a score of +1. Tied values are given a score of 0. A test statistic ("S") is then computed based on the difference between the number of positive differences and negative differences. S is then compared to a critical value based on a 95% confidence level in order to accept or reject the null hypothesis of no trend (equal numbers of positive and negative differences).

The Sen's slope estimator is a non-parametric alternative for estimating a slope (USEPA 2009). The approach involves computing slopes for all the pairs of ordinal time points and then using the median of these slopes as an estimate of overall slope (USEPA 2009). This approach is insensitive to outliers and can accommodate data sets with a limited number of nondetects (i.e., values less than sample RLs) (USEPA 2009).

If seasonal cycles are present in data, tests for trend that remove these cycles or are not affected by them should be used (Gilbert 1987). The SK test was developed by the USGS and is a standard test for evaluating seasonal patterns in water quality data. This test has been applied since the early 1980s to the USGS collection of long-term water-quality records across the United States. A number of statistical software packages are available to perform the SK test, including SYSTAT version 13, (SYSTAT 2010) that was used for this analysis.

A minimum of n=4 sampling events per well is recommended to run the MK and Sen's slope tests. If the data contain nondetects, a minimum of n=4 detects is recommended, and the RLs of nondetects should be closely evaluated to determine the influence of nondetects on the slopes (e.g., historical data with high RLs).

Data Distribution Testing

GOF testing was performed to determine if parametric or nonparametric statistical methods were most appropriate for calculating UPLs. Consistent with USEPA (2009) guidance, data were evaluated for fits to normal, lognormal, and gamma distributions at an alpha level (α) of 0.05 (95% significance level). Using USEPA's ProUCL 4.1 software (USEPA 2010), optimal statistical tests were applied depending on distribution and sample size (n) (e.g., normal and lognormal: Shapiro-Wilk [SW] test for $n \le 50$ or Lilliefors test for $n > 50$; gamma: Kolmogorov-Smirnov [KS] test). For this analysis, no datasets contained more than 50 values.

Probability plots (or p-plots) serve multiple purposes in exploratory data analysis (EDA) for establishing background conditions. They allow for a visual inspection of the data distribution, which complements formal statistical tests for GOF. Inflection points or changes in slope can indicate that the data represent a mixture of multiple populations, which may reflect multiple background sources or a combination of background and site-related sources. Finally, p-plots can be used to identify extreme values in the upper tail of a distribution, which may be indicative of suspected outliers. The identification of potential outliers is the first step in an outlier analysis, which was an important component of EDA of background data.

Quantile plots were generated for this analysis to evaluate fits to normal, lognormal, and gamma distributions. Quantile plots show the quantiles of the empirical distribution versus the quantiles of the hypothesized distribution. A straight-line fit on a quantile plot provides evidence that the data were collected from a single population with the specified distribution. For this analysis the distribution was based on the SW test for normality and the KS test for gamma distributed data ($\alpha = 0.05$). Distributions were confirmed by inspecting the respective quantile plots.

Dataset Definition

UPLs were developed for cyanide, fluoride, and sulfate in six monitoring wells (MW-17S, MW-22S, MW-23S, MW-35S, MW-36S, and MW-37S). One additional well (MW-5S) is an upgradient well and will be used to help detect an offsite release or background conditions that may influence downgradient wells. Any SSI in downgradient wells should be evaluated against recent and historical data in MW-5S to detect future onsite contamination from any potential alternate source areas should it occur. Historical data are available beginning in 1986 and 1987 for wells MW-5S, MW-17S, MW-22S, and MW-23S. Historical data for MW-36S and MW-37S are available beginning in the spring of 2001. All three constituents in these wells have been statistically decreasing or have no statistically significant trend over the historical time-period.

Typically more data are generally preferable when computing UPLs (USEPA 2009). However, the historical data likely reflect historical impacts from other areas of the site and were not used for developing UPLs. Therefore, the dataset was initially truncated to the most recent 16 samples. Using the most recent 16 samples has several advantages. First, the number 16 is two times the suggested minimum of 8 samples recommended by the USEPA UG (USEPA 2009). Second, keeping the number of samples equal in all data sets simplifies the SWFPR calculation. Lastly, most recent data points are the ones that give the most relevant UPL or the best indication of an increasing trend. The raw data for the most recent 16 samples that were used in the analysis are included as Attachment A. Additional data conditioning steps completed prior to statistical analysis are described below.

Treatment of Field Duplicate Samples

All statistics were calculated on datasets using parent samples only. Recent USEPA guidance discourages averaging duplicate samples and suggests either selecting a parent or duplicate sample at random unless duplicates are collected for each field sample (USEPA 2009). Assuming that a parent and a field duplicate sample could be considered random samples at the same location, a straightforward way to deal with duplicates is to consider the parent sample only, which is essentially a random sample. However, the variability between parent samples and field duplicates should be evaluated during the data evaluation process to ensure the analytical data meet data quality objectives of the monitoring program.

Treatment of Non-detects

Statistical analysis, including GOF testing and UPL estimation, can be challenging for left-censored data (i.e., data with nondetects [NDs]). In general, methods consistent with USEPA (2009) were employed using ProUCL 4.1 (USEPA 2010), including evaluating distributions and censored p-plots based on ROS methods (i.e., extrapolation of NDs based on p-plot of uncensored data). Guidance on statistical analysis of left-censored data has evolved to reflect results of more thorough testing of the performance of alternative approaches. USEPA (2006) summarizes the results of numerical experiments with datasets representing a wide range of censoring, sample sizes, and distribution shapes. Previously, it was commonly assumed that substitution methods (e.g., using one-half the MRL for NDs, or "DL/2 method") introduced marginal bias. Based on this assumption, USEPA (2006) and other agencies previously recommended using substitution methods under conditions of moderate censoring (e.g., less than 15 to 20%). However, USEPA (2009) demonstrated through numerical experiments that the DL/2 method clearly does not provide adequate coverage for any distribution and sample size, even for censoring levels as low as 5%. Furthermore, the coverage of a confidence interval or tolerance limit (e.g., 95% interval that encloses the parameter of interest) provided by the DL/2 method deteriorates quickly as the censoring intensity increases. Based on USEPA (2009, 2010) non-detects were included at their respective RLs, and non-detects were imputed for the purposes of GOF testing and UPL estimation.

Results of Statistical Analysis

Proposed UPLs are provided in Table 1 and discussed briefly below. Additional summary statistics, data distributions, and UPL methods are provided in Table A.1.

Table 1 - Upper Prediction Limits for Detecting a Statistically Significant Increase (SSI) at The Dalles

Well	99% Upper Prediction Limit for *k* = 4		
	Cyanide, WAD (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)
MW-17S	0.0073	0.87	75.9
MW-22S	0.053	0.5 (DQR)*	127
MW-23S	0.016	0.5 (DQR)*	71.4
MW-35S	0.012	0.95	139
MW-36S	0.005 (DQR)*	0.5 (DQR)*	183
MW-37S	0.0088	6.3	94.9
MW-5S (upgradient)	0.038	12.8	127

Notes:
* Double quantification rule proposed based on frequency of detection. The RL is listed in the table.

- MW-17S
    - The UPL99 for cyanide is 0.0073 milligrams per liter (mg/L). The UPL99 is based on Kaplan-Meier estimation since the dataset contains nondetects (Figure B.1). Five (31%) of the most recent 16 values were detected and ranged from 0.0056 to 0.0071 mg/L (Figure A.1).
    - The UPL99 for fluoride is 0.87 mg/L and is based on Kaplan-Meier estimation since the dataset contains nondetects (Figure B.1). Ten (63%) of the most recent 16 samples were detected and ranged from 0.51 to 0.73 (Figure A.2).

- The UPL99 for sulfate is 75.9 mg/L and is based on a normal UPL (Figure B.1). All of the most recent 16 samples were detected and ranged from 44.7 to 62.6 (Figure A.3).

- MW-22S

  - The UPL99 for cyanide is 0.053 mg/L. The UPL99 is based on a Kaplan-Meier estimation since the dataset contains nondetects (Figure B.2). Thirteen (81%) of the most recent 16 values were detected and ranged from 0.006 to 0.041 mg/L (Figure A.4).

  - The UPL99 for fluoride is 0.5 mg/L and is based on the agreed upon RL for fluoride in the permit. Three (19%) of the most recent 16 samples were detected and ranged from 0.48 to 0.528, one of which was less than the 0.5 mg/L RL (Figure A.5). The maximum detected value of 0.528 mg/L on March 19, 2009 was a lab estimated value (J flag), while the other the other detected value above the RL was 0.504 taken on September 8, 2004, very early in the dataset. Therefore, the double quantification rule is proposed for fluoride in MW-22S. As per the UG (USEPA 2009), a confirmed exceedance may be registered if the well-constituent pair in the '100% non-detect' group exhibits quantified measurements (i.e., at or above the RL) in two consecutive sample and resample events.

  - The UPL99 for sulfate is 127 mg/L and is based on a normal UPL (Figure B.2). All of the most recent 16 samples were detected and ranged from 55.9 to 104 (Figure A.6). A significant increasing trend was identified with both the Sen's slope estimator and the MK test for sulfate in Well MW-22S. This could result in potential UPL exceedances.

- MW-23S

  - The UPL99 for cyanide is 0.016 mg/L. The UPL99 is based on Kaplan-Meier estimation since the dataset contains nondetects (Figure B.3). Six (38%) of the most recent 16 values were detected and ranged from 0.0058 to 0.013 mg/L (Figure A.7).

  - The UPL99 for fluoride is 0.5 mg/L and is based on the RL for fluoride in the permit. All of the most recent 16 samples were less than the 0.5 mg/L RL (Figure A.8), therefore, the double quantification rule is proposed for fluoride in MW-23S. As per the UG (USEPA 2009), a confirmed exceedance may be registered if the well-constituent pair in the '100% non-detect' group exhibits quantified measurements (i.e., at or above the RL) in two consecutive sample and resample events.

  - The UPL99 for sulfate is 71.4 mg/L and is based on a gamma UPL (Figure B.3). All of the most recent 16 samples were detected and ranged from 29.7 to 53.6 (Figure A.9).

- MW-35S

    - The UPL99 for cyanide is 0.012 mg/L. The UPL99 is based on Kaplan-Meier estimation since the dataset contains nondetects (Figure B.4). Seven (44%) of the most recent 16 values were detected and ranged from 0.005 to 0.011 mg/L (Figure A.10).

    - The UPL99 for fluoride is 0.95 mg/L and is based on nonparametric UPL since the dataset does not fit a normal, gamma, or lognormal distribution (Figure B.4). All of the most recent 16 samples were detected and ranged from 0.53 to 0.95 mg/L (Figure A.11).

    - The UPL99 for sulfate is 139 mg/L and is based on a normal UPL (Figure B.4). All of the most recent 16 samples were detected and ranged from 109 to 129 mg/L (Figure A.12).

- MW-36S

    - The UPL99 for cyanide is 0.005 mg/L and is based on the RL for cyanide in the permit. All of the most recent 16 samples were not detected below the detection limit, although the reporting limit for three samples was higher than 0.005 mg/L. The double quantification rule is proposed for cyanide in MW-36S (Figure A.13). As per the UG (USEPA 2009), a confirmed exceedance may be registered if the well-constituent pair in the '100% non-detect' group exhibits quantified measurements (i.e., at or above the RL) in two consecutive sample and resample events.

    - The UPL99 for fluoride is 0.5 mg/L and is based on the RL for fluoride in the permit. All of the most recent 16 samples were less than the 0.5 mg/L RL (Figure A.14), therefore, the double quantification rule is proposed for fluoride in MW-36S. As per the UG (USEPA 2009), a confirmed exceedance may be registered if the well-constituent pair in the '100% non-detect' group exhibits quantified measurements (i.e., at or above the RL) in two consecutive sample and resample events.

    - The UPL99 for sulfate is 183 mg/L and is based on a normal UPL (Figure B.5). All of the most recent 16 samples were detected and ranged from 85.9 to 157 mg/L (Figure A.15).

- MW-37S

    - The UPL99 for cyanide is 0.0088 mg/L. The UPL99 is based on Kaplan-Meier estimation since the dataset contains nondetects (Figure B.6). Seven (47%) of the most recent 16 values were detected and ranged from 0.0054 to 0.0079 mg/L (Figure A.16). It should be noted that an additional sample was collected in May 2009 at the same time of the additional fluoride re-sample described below. The original lower (March 2009) sample was used for calculating UPLs.

- The UPL99 for fluoride is 6.3 mg/L and is based on a normal distribution (Figure B.6). All of the most recent 16 samples were detected and ranged from 3.0 to 5.5 mg/L (Figure A.17).

  It should be noted that in 2009 a total of three samples were collected at this well, however, only the May and September results were used while the March value was excluded. As noted in the Consolidated Report for that period "*Laboratory analytical results for a groundwater sample collected on March 18, 2009, from well MW-37S indicated a fluoride concentration of 8.92 mg/L. That concentration was around twice the median concentration for fluoride in that well. An additional groundwater sample was collected on May 21, 2009, that had a laboratory analytical result for fluoride of 5.47 mg/L. The groundwater sample collected on September 16, 2009, had a laboratory analytical result for fluoride of 4.48 mg/L, indicating that the fluoride result from the March, 2009, monitoring event was an outlier, rather than indication of an upward trend.*" For conservative purposes, the lower (May 2009) value was used in place of the March 2009 value for calculating UPLs. Similarly, in June 2011 an additional fluoride sample was collected to check the 10.4 mg/L result collected in March 2011. The June resample was equal to 3.92 mg/L and was used in place of the 10.4 mg/L result for purposes of calculating statistics.

- The UPL99 for sulfate is 94.9 mg/L and is based on a gamma distribution (Figure B.6). All of the most recent 16 samples were detected and ranged from 22.5 to 88.9 (Figure A.18). It should be noted that an additional sample was collected in May 2009 at the same time of the additional fluoride sample described above. The original lower (March 2009) sample was used for calculating UPLs.

- <u>MW-5S</u> – This well is an upgradient well that will be used to help detect future onsite contamination from any potential alternate source areas should it occur.

  - The UPL99 for cyanide is 0.038 mg/L. The UPL99 is based on Kaplan-Meier estimation since the dataset contains nondetects (Figure B.7). Twelve (75%) of the most recent 16 values were detected and ranged from 0.005 to 0.030 mg/L (Figure A.19).

  - The UPL99 for fluoride is 12.8 mg/L and is based on a normal distribution (Figure B.7). All of the most recent 16 samples were detected and ranged from 3.8 to 10.2 mg/L (Figure A.20).

  - The UPL99 for sulfate is 127 mg/L and is based on a normal distribution (Figure B.7). All of the most recent 16 samples were detected and ranged from 35.4 to 102 (Figure A.21).

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Conclusion

As requested by the ODEQ, this memo presented a summary of the UPL99 to be used in detection monitoring to support permit renewal at The Dalles. An intrawell analysis was completed to derive statistically based criteria to detect an SSI for several indicator constituents monitored as part of the groundwater monitoring at the Lockheed Martin Hazardous Waste RCRA landfill located in The Dalles, Oregon.

UPLs were developed for cyanide, fluoride, and sulfate in six monitoring wells (MW-17S, MW-22S, MW-23S, MW-35S, MW-36S, and MW-37S) and one additional upgradient well (MW-5S) that is being used to help detect background conditions or an offsite release that may influence downgradient wells. Statistical analysis followed the methods outlined in "*Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities.*" (USEPA 2009). For this analysis, a *k*-factor of 4 was used such that a well and constituent is expected to be below the UPL with 99% confidence for the next four samples.

The detection monitoring program proposed is only to help detect an SSI, not necessarily that a release from the landfill has occurred. The program includes a 1-of-2 retesting schedule which means that if 1-of-2 resamples following an exceedance is within bounds, the well is considered to "pass" the test with no SSI. If an SSI is detected in future monitoring, it does not imply or prove that contaminated groundwater at the facility is the cause of the increase. Refer to Chapter 4 of the UG (USEPA 2009) for factors to consider before an SSI can be considered a site-related release.

References

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Attachment A

Table A.1. Upper Prediction Limits for Detecting a Statistically Significant Increase (SSI) at The Dalles[1].

Well	Analyte	Figure	Date Range	FOD	FOD %	RL Range	Detect Range	Sen's Slope Conclusion[2]	GOF[3]	GOF Figure	UPL Method[4]	UPL95[6]	UPL99[6]
MW-17S	Cyanide (WAD)	A.1	4/04 - 9/11	5 / 16	31%	0.005 - 0.025	0.0056 - 0.0071	No trend	N/Ln	B.1	KM UPL	0.0069	0.0073
	Fluoride	A.2	4/04 - 9/11	10 / 16	63%	0.5	0.51 - 0.73	No Trend	N/G/Ln	B.1	KM UPL	0.80	0.87
	Sulfate	A.3	4/04 - 9/11	16 / 16	100%	NA	44.7 - 62.6	Decreasing	N/G/Ln	B.1	Normal UPL	71.1	75.9
MW-22S	Cyanide (WAD)	A.4	4/04 - 9/11	13 / 16	81%	0.005 - 0.036	0.0060 - 0.041	Decreasing	N/Ln	B.2	KM UPL	0.045	0.053
	Fluoride	A.5	4/04 - 9/11	3 / 16	19%	0.5	0.48 - 0.53	No Trend	NA	NA	DQR[4,5]	0.5	0.5
	Sulfate	A.6	4/04 - 9/11	16 / 16	100%	NA	55.9 - 104	Increasing	N/G/Ln	B.2	Normal UPL	115	127
MW-23S	Cyanide (WAD)	A.7	4/04 - 9/11	6 / 16	38%	0.005 - 0.025	0.0058 - 0.013	No trend	N/Ln	B.3	KM UPL	0.014	0.016
	Fluoride	A.8	4/04 - 9/11	2 / 16	13%	0.5	0.23 - 0.25	No trend	NA	NA	DQR[4]	0.5	0.5
	Sulfate	A.9	4/04 - 9/11	16 / 16	100%	NA	29.7 - 53.6	Decreasing	G	B.3	Gamma UPL	64.6	71.4
MW-35S	Cyanide (WAD)	A.10	4/04 - 9/11	7 / 16	44%	0.005 - 0.025	0.0050 - 0.011	No trend	N/Ln	B.4	KM UPL	0.010	0.012
	Fluoride	A.11	4/04 - 9/11	16 / 16	100%	NA	0.53 - 0.95	No trend	NP	B.4	NP UPL	0.95	0.95
	Sulfate	A.12	4/04 - 9/11	16 / 16	100%	NA	109 - 129	Decreasing	N/G/Ln	B.4	Normal UPL	134	139
MW-36S	Cyanide (WAD)	A.13	4/04 - 9/11	0 / 16	0%	0.005 - 0.025	NA	No trend	NA	NA	DQR[4]	0.005	0.005
	Fluoride	A.14	4/04 - 9/11	2 / 16	13%	0.5	0.21 - 0.21	No trend	NA	NA	DQR[4]	0.5	0.5
	Sulfate	A.15	4/04 - 9/11	16 / 16	100%	NA	85.9 - 157	Decreasing	N/G/Ln	B.5	Normal UPL	167	183
MW-37S	Cyanide (WAD)	A.16	4/04 - 9/11	7 / 16	44%	0.005 - 0.018	0.0054 - 0.0079	No trend	N/Ln	B.6	KM UPL	0.0081	0.0088
	Fluoride	A.17	4/04 - 9/11	16 / 16	100%	NA	3.0 - 5.5	No Trend	N/G/Ln	B.6	Normal UPL	5.8	6.3
	Sulfate	A.18	4/04 - 9/11	16 / 16	100%	NA	22.5 - 88.9	No Trend	G	B.6	Gamma UPL	76.2	94.9
MW-5S	Cyanide (WAD)	A.19	4/04 - 9/11	12 / 16	75%	0.005 - 0.025	0.0050 - 0.030	Decreasing	N/Ln	B.7	KM UPL	0.032	0.038
	Fluoride	A.20	4/04 - 9/11	16 / 16	100%	NA	3.8 - 10.2	No Trend	N/G/Ln	B.7	Normal UPL	11.2	12.8
	Sulfate	A.21	4/04 - 9/11	16 / 16	100%	NA	35.4 - 102	No Trend	N/G/Ln	B.7	Normal UPL	113	127

Abbreviations

-- = not applicable (FOD = 100%)
DQR = double quantification rule
FOD = frequency of detections (# detects / # samples)
GOF = goodness-of-fit test
NA = insufficient # detects to evaluate GOF

RL = reporting limit
KM = Kaplan-Meier
NP = nonparametric
UPL95 = 95% upper prediction limit
UPL99 = 99% upper prediction limit
WAD = Weak Acid Dissociable

Refer to following page for notes

Table A.1. Upper Prediction Limits for Detecting a Statistically Significant Increase (SSI) at The Dalles[1].

Notes

[1] All results are reported in milligrams per liter (mg/L).

[2] Sen's slope estimator used to test for increasing trend ($\alpha = 0.05$).
Nondetects set equal to a common value less than the minimum detection (USEPA 2009).

[3] Distribution assessed by GOF test method and quantile plots using ProUCL 4.1 at a 95% confidence level ($\alpha = 0.05$).
GOF estimated by ROS for datasets including nondetects (USEPA 2010).

Distributions:

Gamma (G): gamma distribution based on Kolmogorov-Smirnov Test
Normal (N): normal distribution based on Shapiro Wilks Test ($n \leq 50$) or Lilliefors Test ($n>50$)
Lognormal (Ln): lognormal distribution based on Shapiro Wilks Test ($n \leq 50$) or Lilliefors Test ($n>50$)
Nonparametric (NP): data set is not normal, lognormal, or gamma; or fewer than 5 detects

[4] UPL method based on frequency of detection and data distribution using the following criteria:

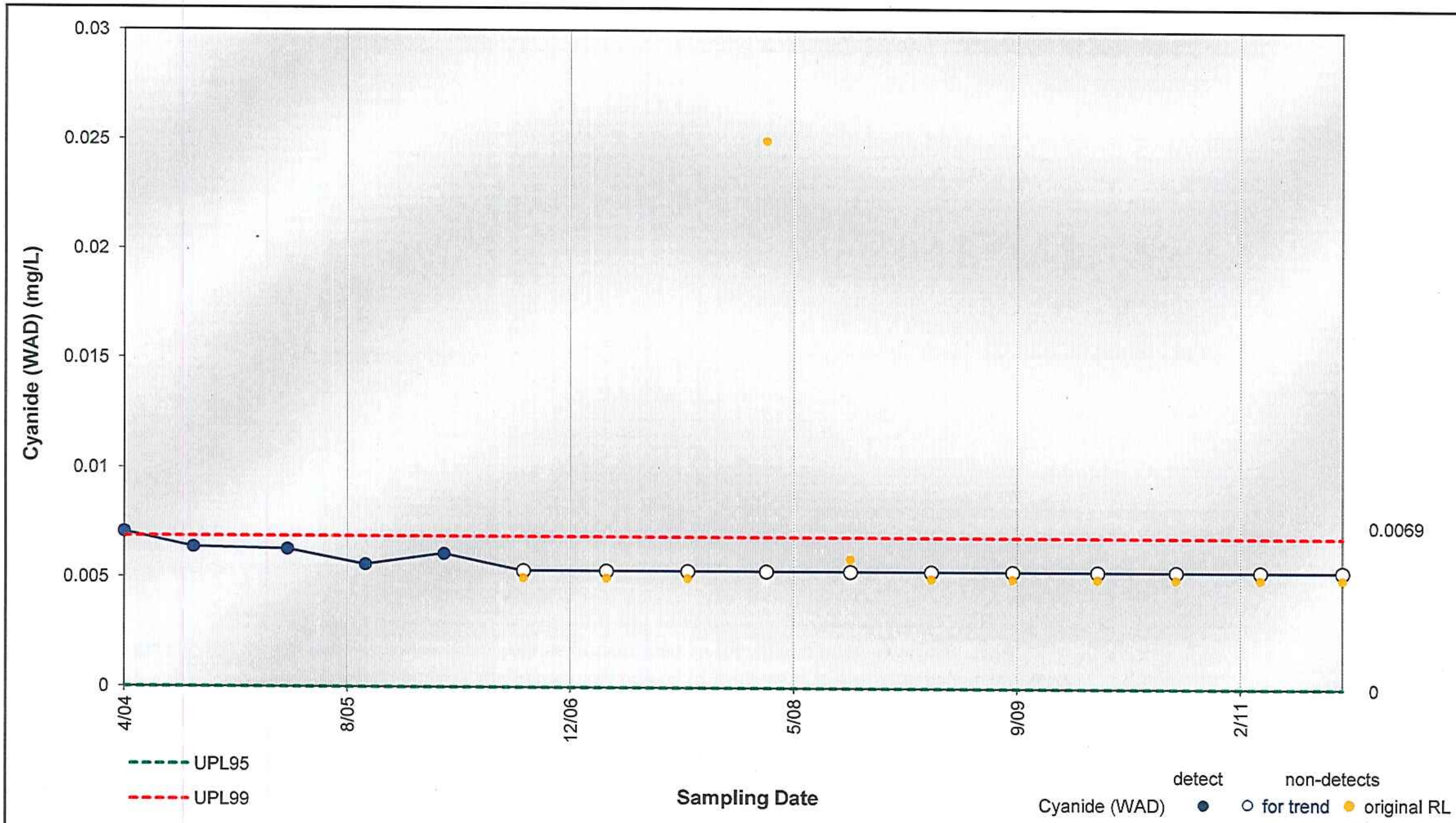
- 100% FOD: Parametric UPL for datasets that fit a Normal, Gamma, or Lognormal distribution, otherwise nonparametric UPL.
- <100% FOD: Non-parametric UPL estimated using Kaplan-Meier methods for nondetects (USEPA 2010).
- 0% FOD for 8-10 of the most recent samples: Double quantification rule (DQR). **Permit reporting limit provided as the UPL in the table.**

[5] DQR invoked due to only one detection of 0.528 mg/L in the most recent 10 samples and was a lab estimated value.

[6] Values less than 10 rounded to two significant digits. Values greater than 10 rounded to three significant digits.

References

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Unified Guidance. EPA/530/R-09/007, 2009.
USEPA. 2010. ProUCL Version 4.1.00 Technical Guide. Office of Research and Development. EPA/600/R-07/041. May.



Results of Mann-Kendall Test for Trend:	**DECREASING TREND**			
	p value =	<0.001	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).	
Results of Sen's Estimator of Slope:	**No trend**			
	Median Slope Estimate =	-1.8E-07	mg/L Per Day	
	95% Confidence Interval =	-5.3E-07	to 0.0E+00	mg/L Per Day

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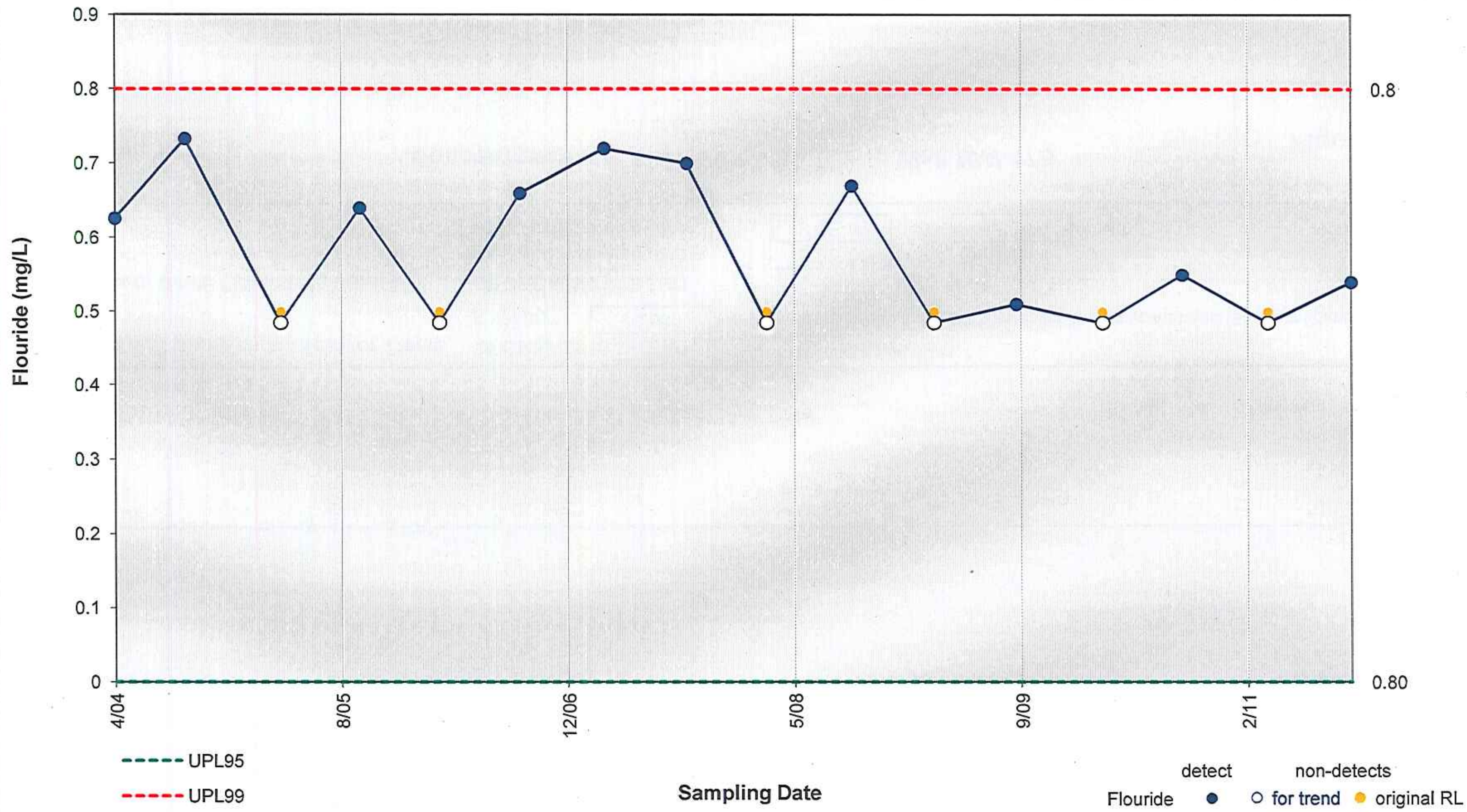
Concentration vs. Time Plot – Cyanide (WAD) in Well MW-17S

LMC - The Dalles

Figure A.1



Results of Mann-Kendall Test for Trend:	**No Significant Trend**				
	p value =	0.133	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).		
Results of Sen's Estimator of Slope:	**No Significant Trend**				
	Median Slope Estimate =	-3.8E-05	mg/L Per Day		
	95% Confidence Interval =	-1.1E-04	to	1.4E-05	mg/L Per Day

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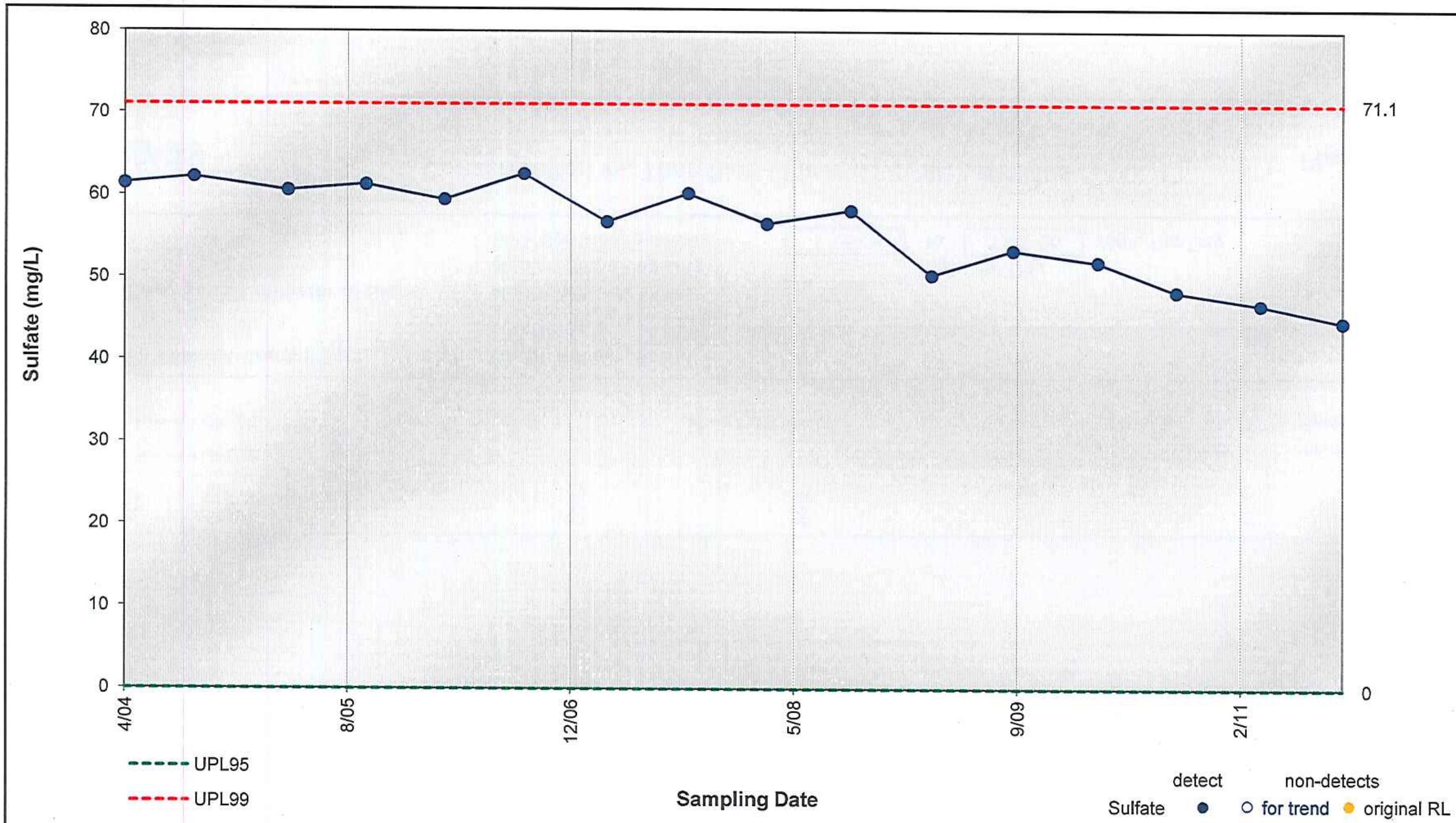
Concentration vs. Time Plot – Fluoride in Well MW-17S

LMC - The Dalles

Figure A.2



Results of Mann-Kendall Test for Trend:	**DECREASING TREND**			
	p value =	<0.001	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).	
Results of Sen's Estimator of Slope:	**DECREASING TREND**			
	Median Slope Estimate =	-6.2E-03	mg/L Per Day	
	95% Confidence Interval =	-8.3E-03	to -4.5E-03	mg/L Per Day

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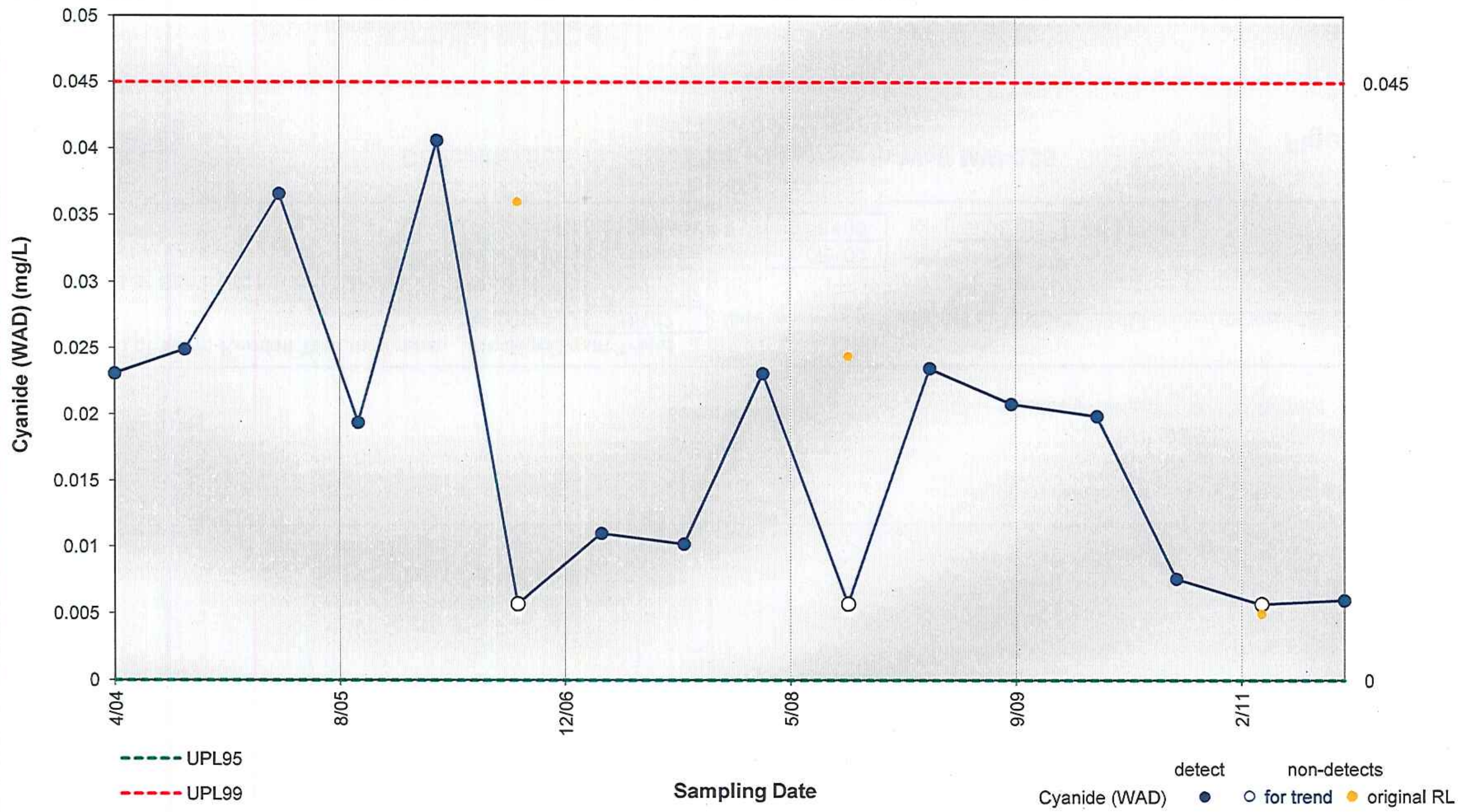
Concentration vs. Time Plot – Sulfate in Well MW-17S

LMC - The Dalles

Figure A.3



Results of Mann-Kendall Test for Trend: **DECREASING TREND**

p value = 0.019 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **DECREASING TREND**

Median Slope Estimate = -6.7E-06 mg/L Per Day

95% Confidence Interval = -1.3E-05 to -2.9E-07 mg/L Per Day

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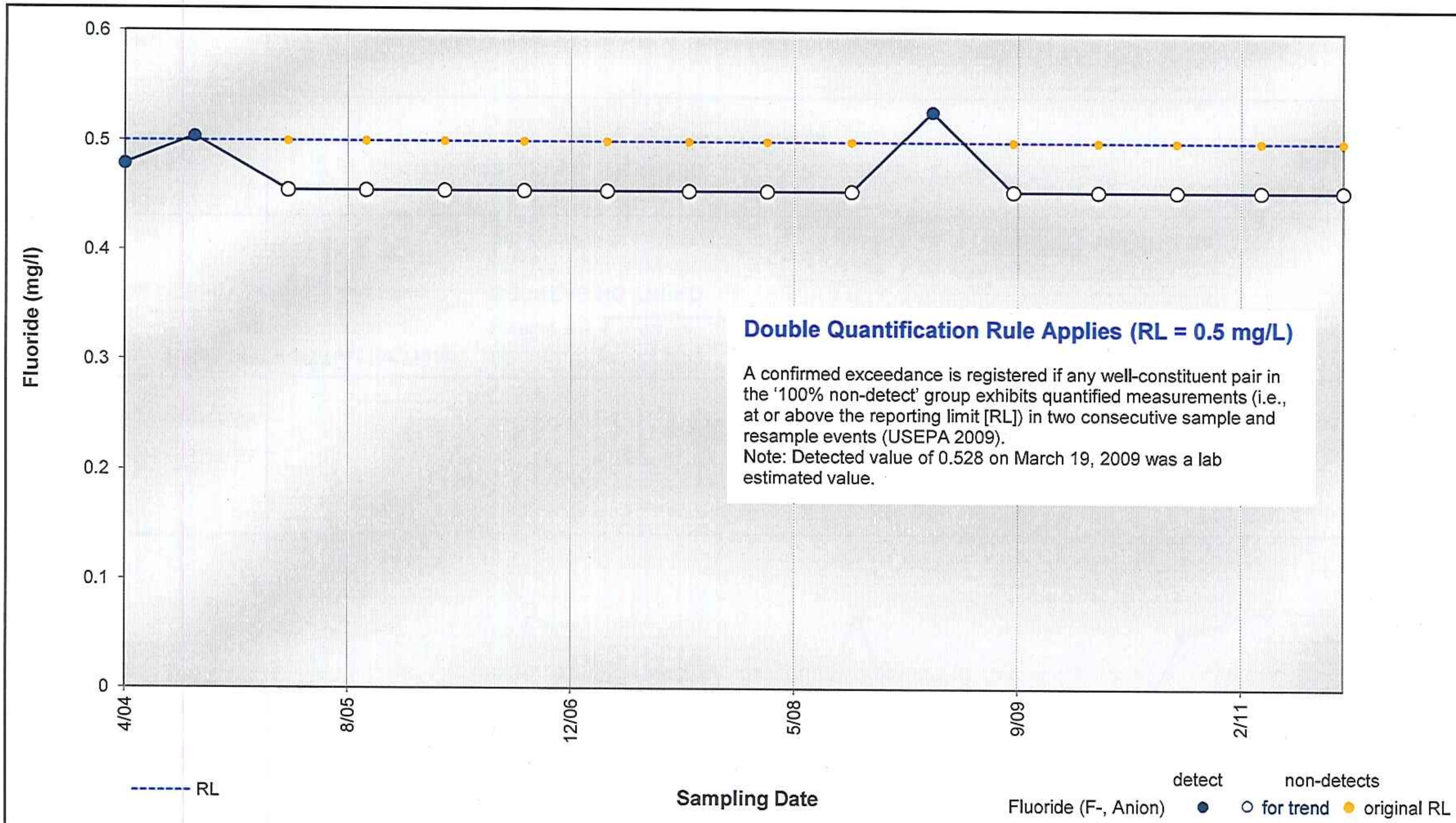
Concentration vs. Time Plot – Cyanide (WAD) in Well MW-22S

LMC - The Dalles

Figure A.4



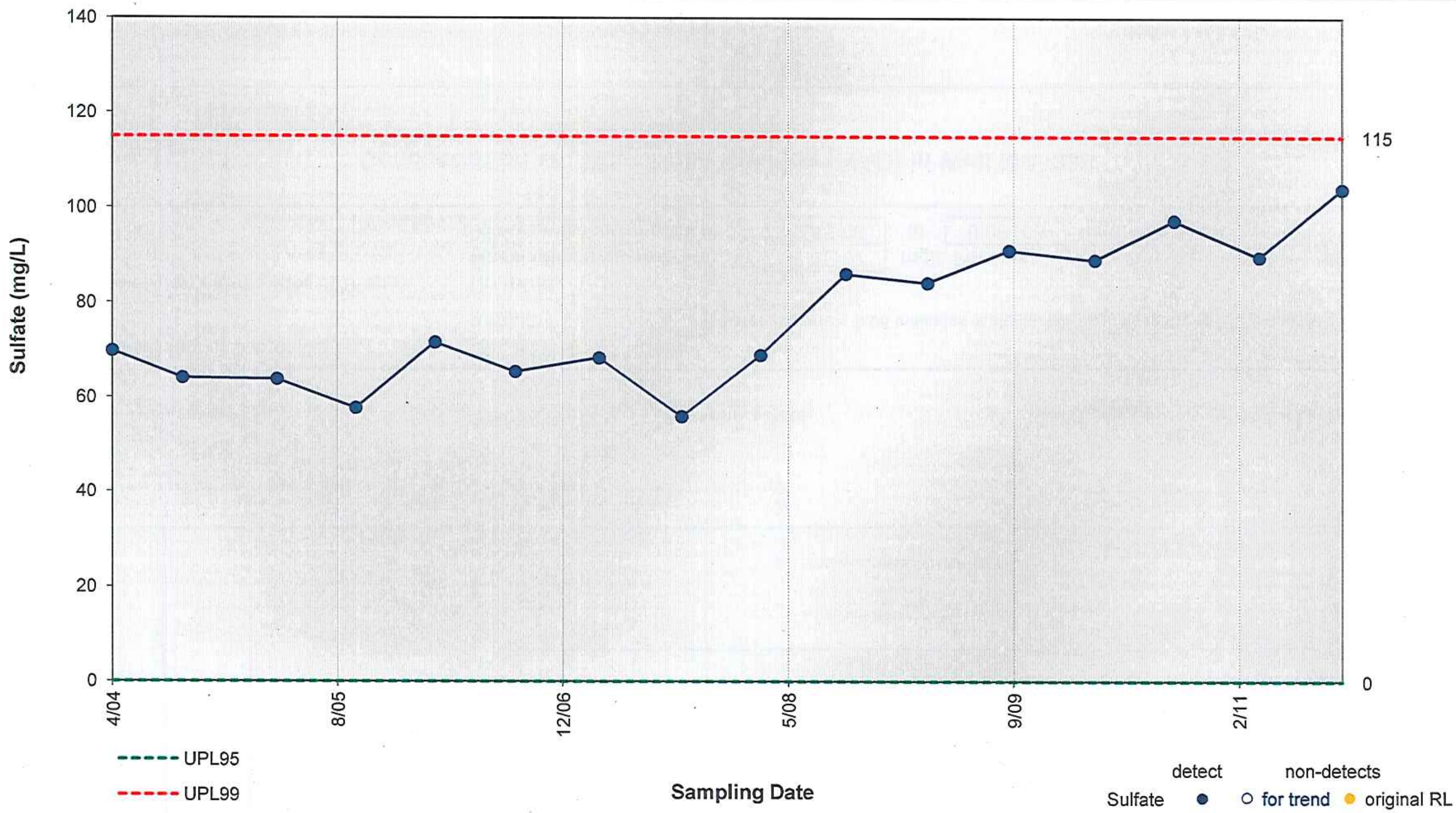
Results of Mann-Kendall Test for Trend:	**No Significant Trend**			
	p value =	0.102	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).	
Results of Sen's Estimator of Slope:	**No trend**			
	Median Slope Estimate =	0.0E+00	mg/l Per Day	
	95% Confidence Interval =	0.0E+00	to 0.0E+00	mg/l Per Day

ARCADIS

Concentration vs. Time Plot – Fluoride in Well MW-22S

LMC - The Dalles

Figure A.5



Results of Mann-Kendall Test for Trend:	**INCREASING TREND**			
	p value =	<0.001	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).	
Results of Sen's Estimator of Slope:	**INCREASING TREND**			
	Median Slope Estimate =	1.5E-02	mg/L Per Day	
	95% Confidence Interval =	8.2E-03	to 2.0E-02	mg/L Per Day

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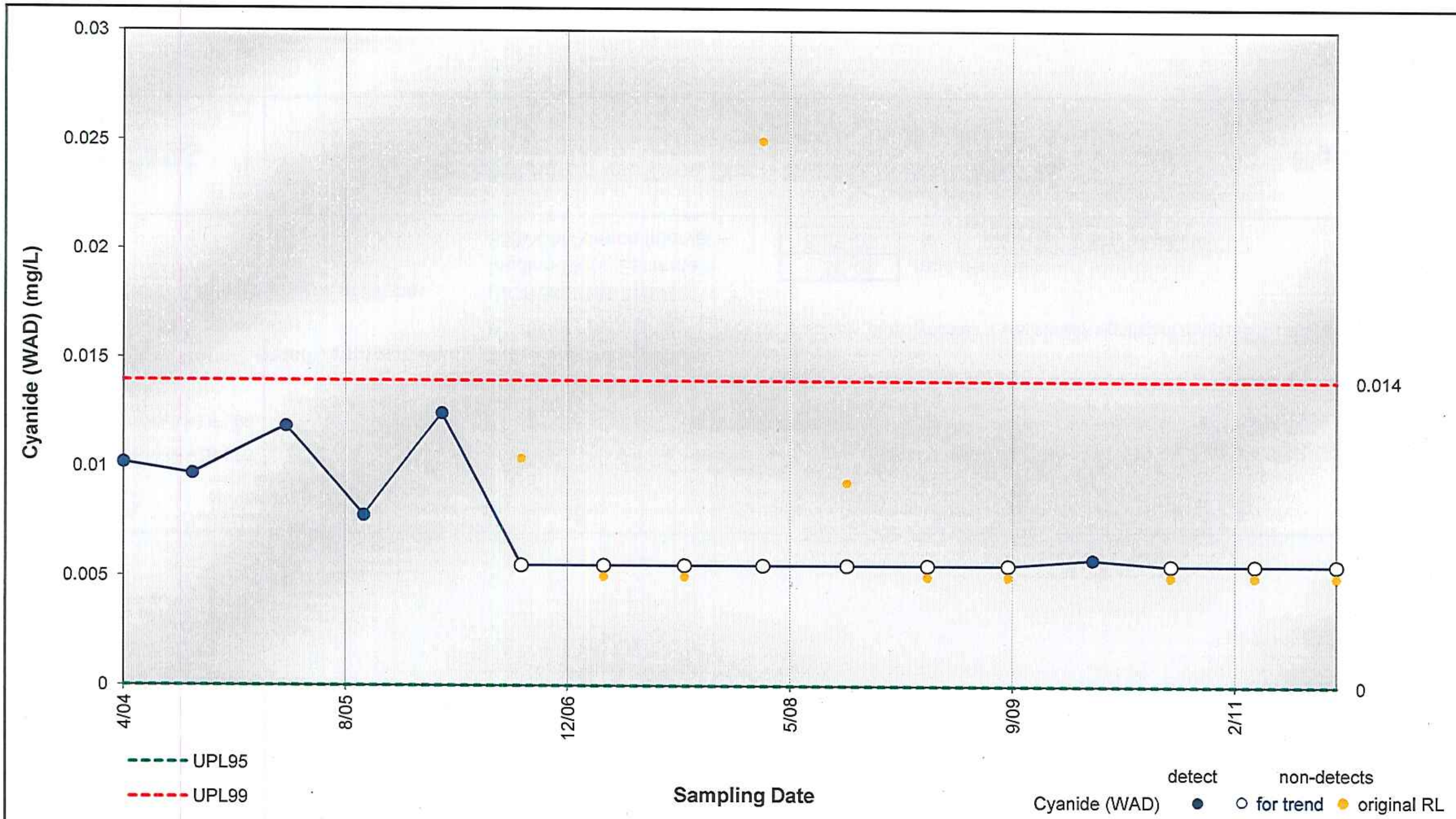
Concentration vs. Time Plot – Sulfate in Well MW-22S

LMC - The Dalles

Figure A.6



Results of Mann-Kendall Test for Trend: **DECREASING TREND**

p value = 0.006 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **No trend**

Median Slope Estimate = -9.2E-07 mg/L Per Day

95% Confidence Interval = -2.5E-06 to 0.0E+00 mg/L Per Day

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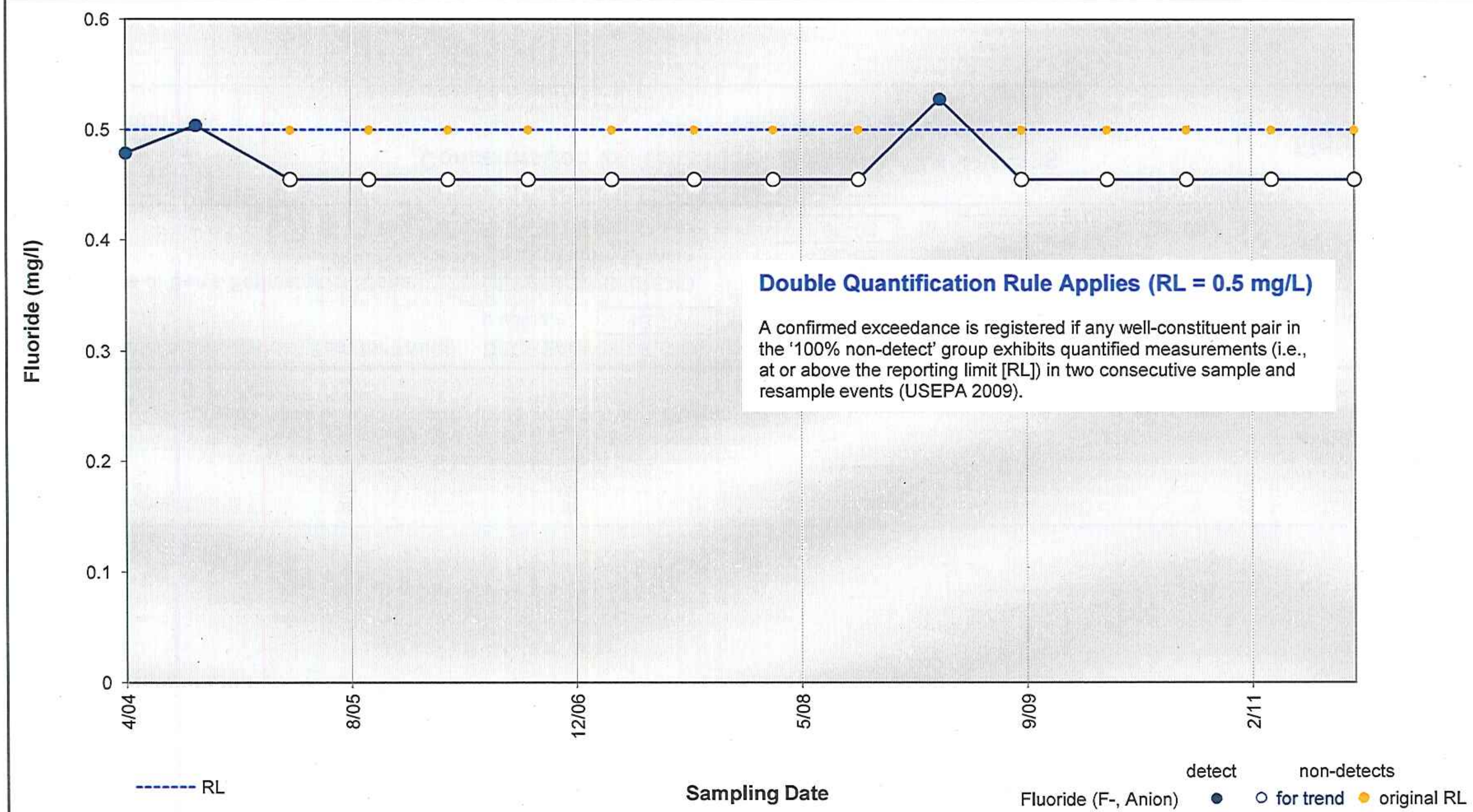
Concentration vs. Time Plot – Cyanide (WAD) in Well MW-23S

LMC - The Dalles

Figure A.7



Results of Mann-Kendall Test for Trend: **No Significant Trend**

p value = 0.102 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **No trend**

Median Slope Estimate = 0.0E+00 mg/l Per Day

95% Confidence Interval = 0.0E+00 to 0.0E+00 mg/l Per Day

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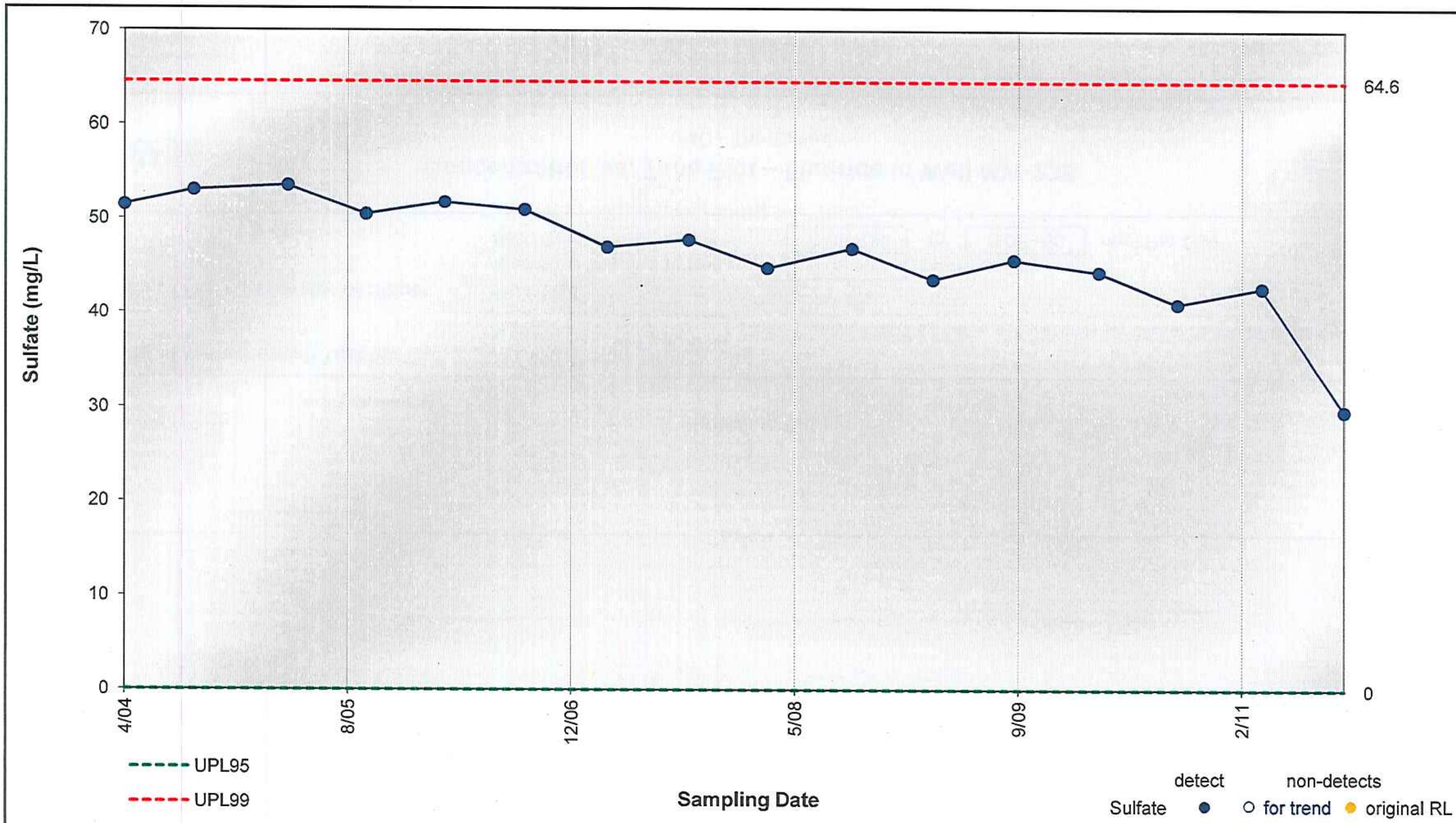
Concentration vs. Time Plot – Fluoride in Well MW-23S

LMC - The Dalles

Figure A.8



Results of Mann-Kendall Test for Trend: **DECREASING TREND**

p value = <0.001 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **DECREASING TREND**

Median Slope Estimate = -4.9E-03 mg/L Per Day

95% Confidence Interval = -6.6E-03 to -4.0E-03 mg/L Per Day

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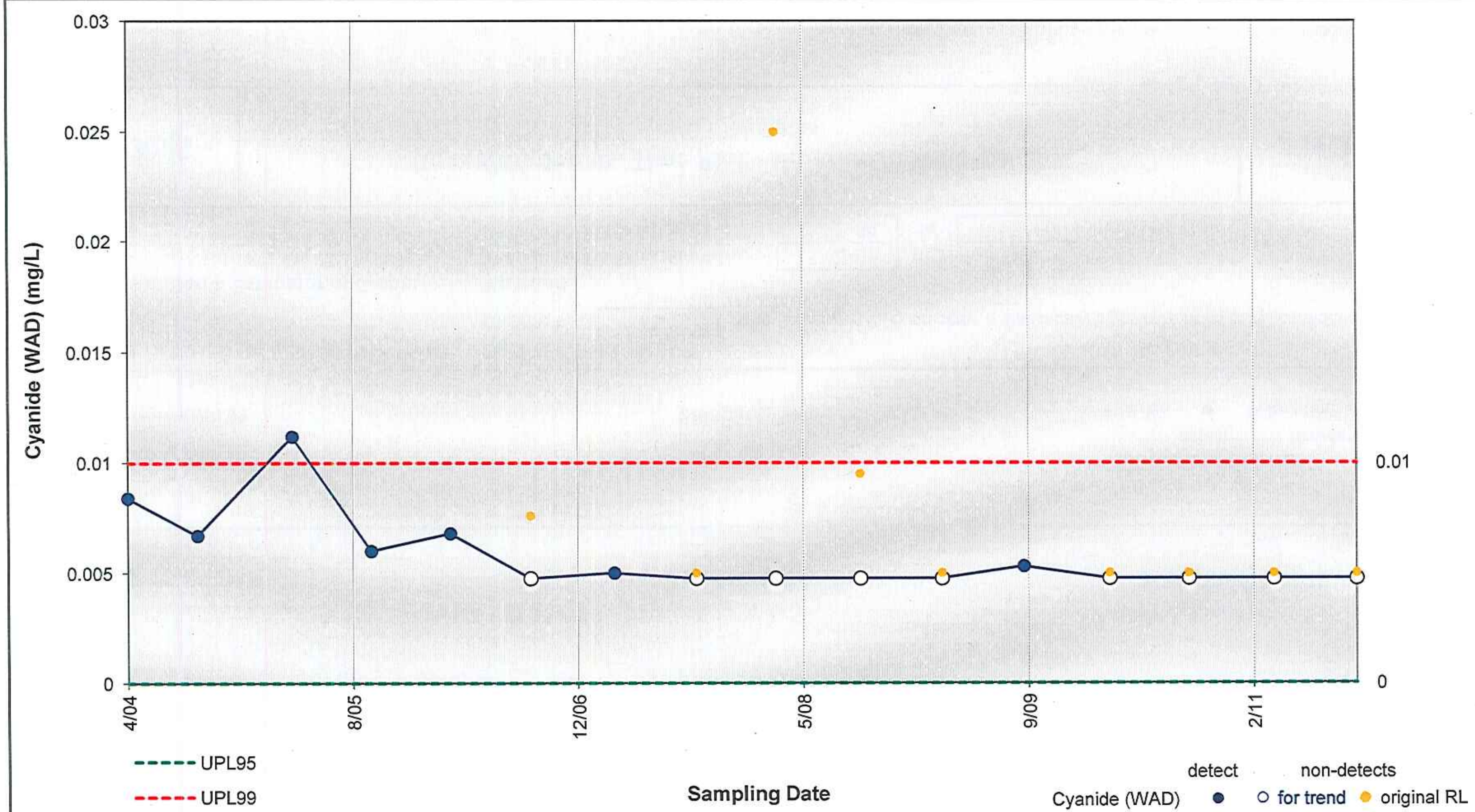
Concentration vs. Time Plot – Sulfate in Well MW-23S

LMC - The Dalles

Figure A.9



Results of Mann-Kendall Test for Trend: **DECREASING TREND**

p value = 0.001 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **No trend**

Median Slope Estimate = -7.6E-07 mg/L Per Day

95% Confidence Interval = -1.5E-06 to 0.0E+00 mg/L Per Day

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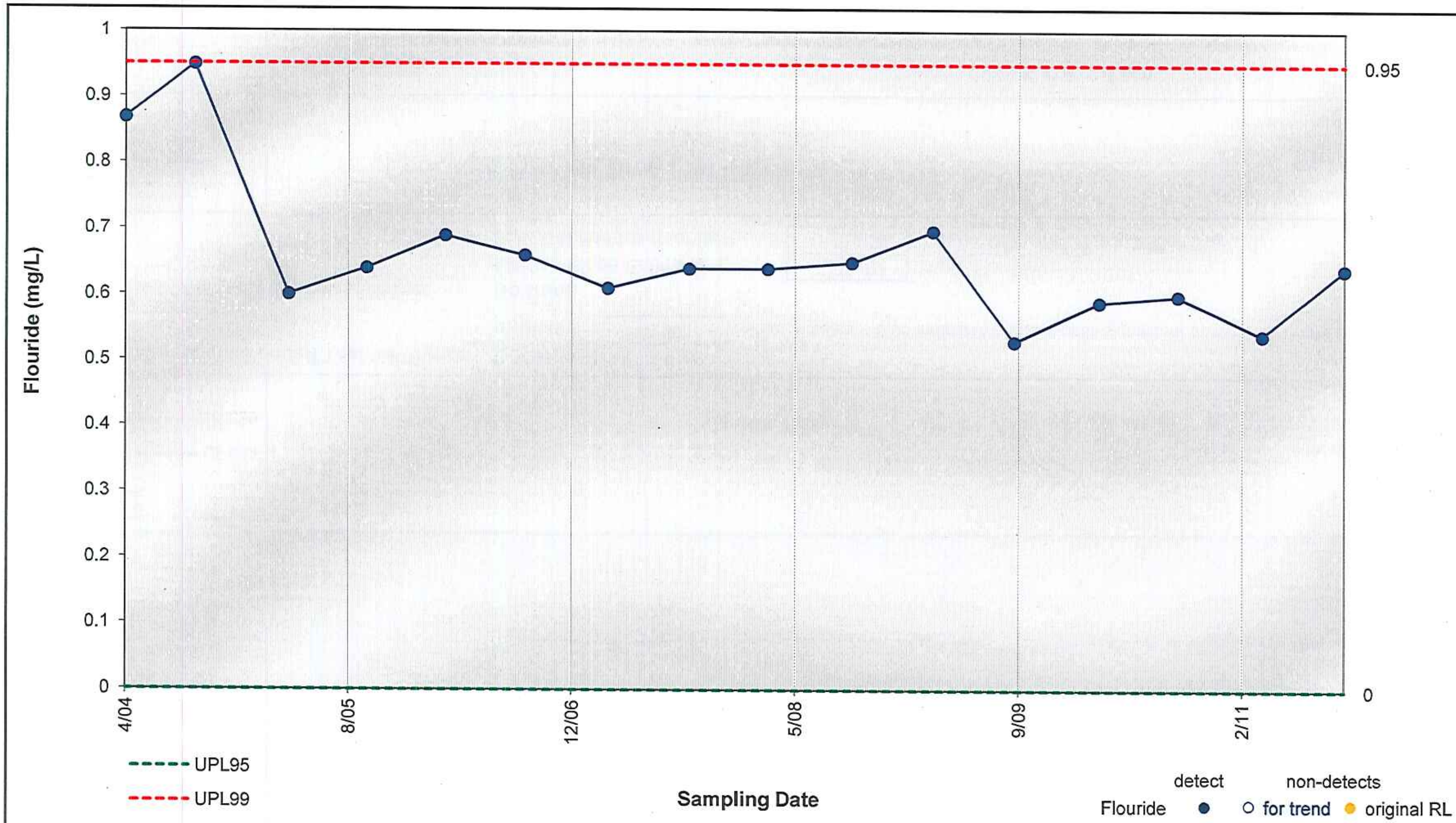
Concentration vs. Time Plot – Cyanide (WAD) in Well MW-35S

LMC - The Dalles

Figure A.10



Results of Mann-Kendall Test for Trend:	**DECREASING TREND**			
	p value =	0.023	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).	
Results of Sen's Estimator of Slope:	**No trend**			
	Median Slope Estimate =	-5.4E-05	mg/L Per Day	
	95% Confidence Interval =	-1.2E-04	to 0.0E+00	mg/L Per Day

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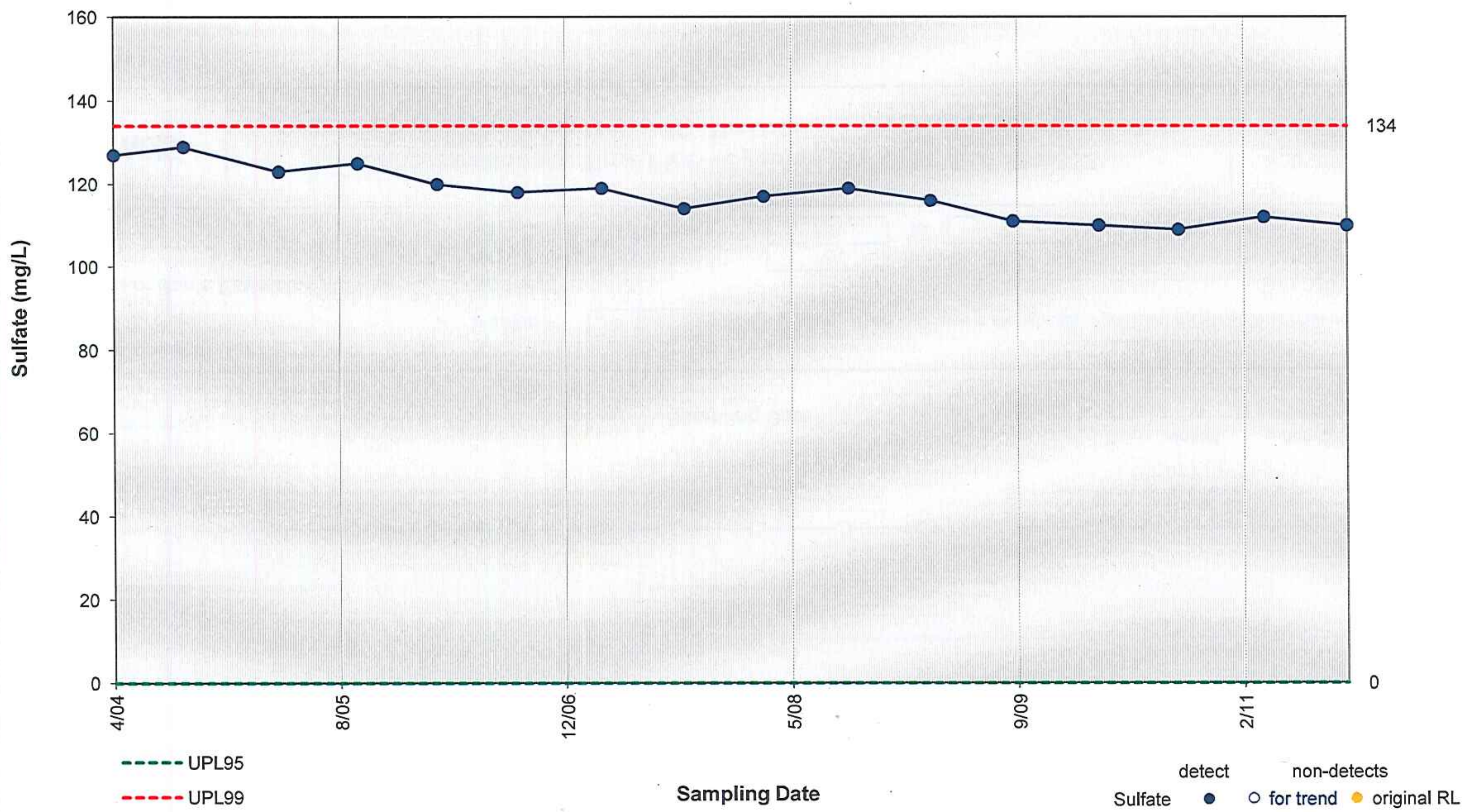
Concentration vs. Time Plot – Fluoride in Well MW-35S

LMC - The Dalles

Figure A.11



Results of Mann-Kendall Test for Trend: **DECREASING TREND**

p value = <0.001 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **DECREASING TREND**

Median Slope Estimate = -6.8E-03 mg/L Per Day

95% Confidence Interval = -8.8E-03 to -5.1E-03 mg/L Per Day

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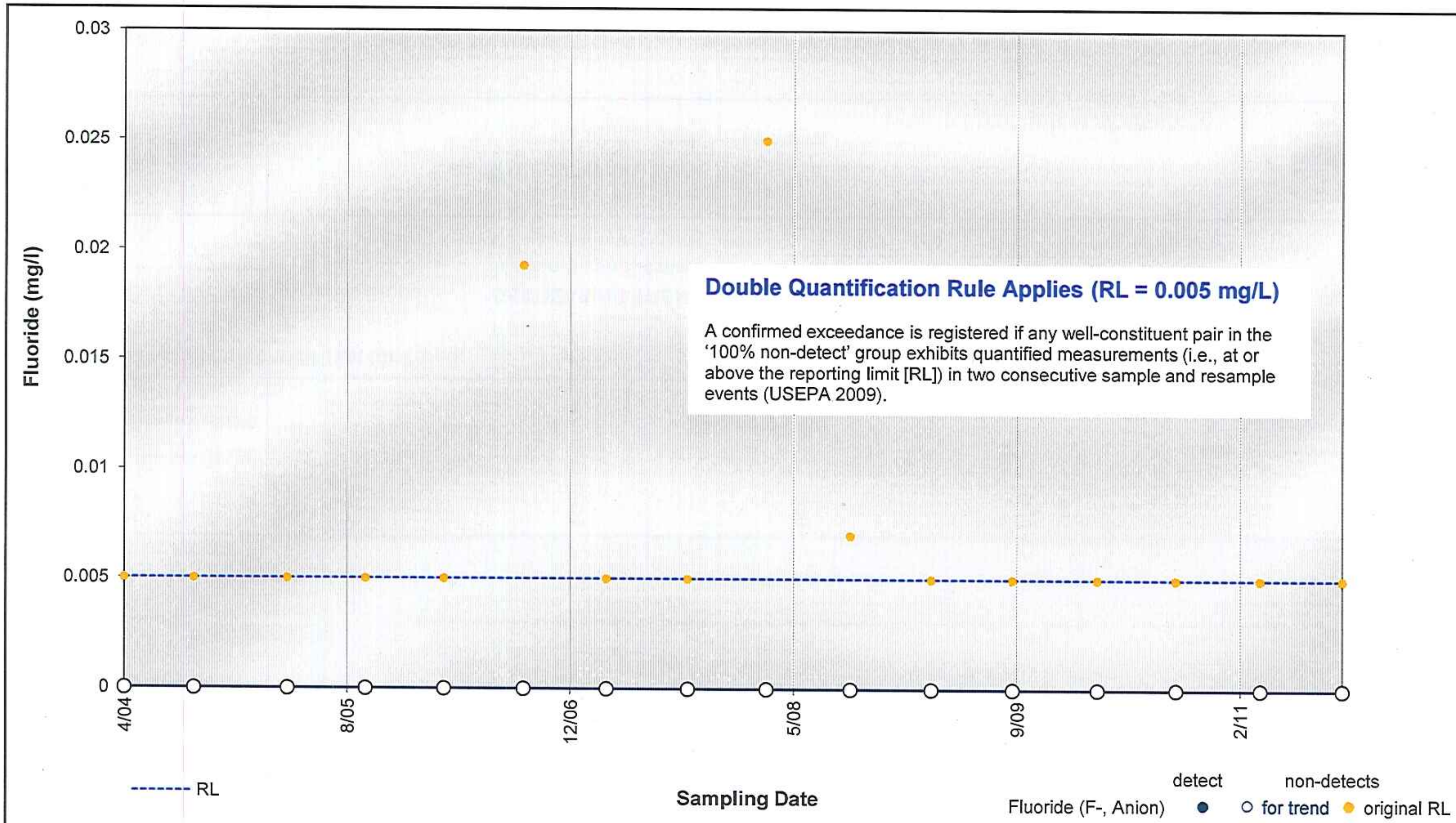
Concentration vs. Time Plot – Sulfate in Well MW-35S

LMC - The Dalles

Figure A.12



Results of Mann-Kendall Test for Trend: **NA**

p value = NA Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **No trend**

Median Slope Estimate = NA mg/l Per Day

95% Confidence Interval = NA to NA mg/l Per Day

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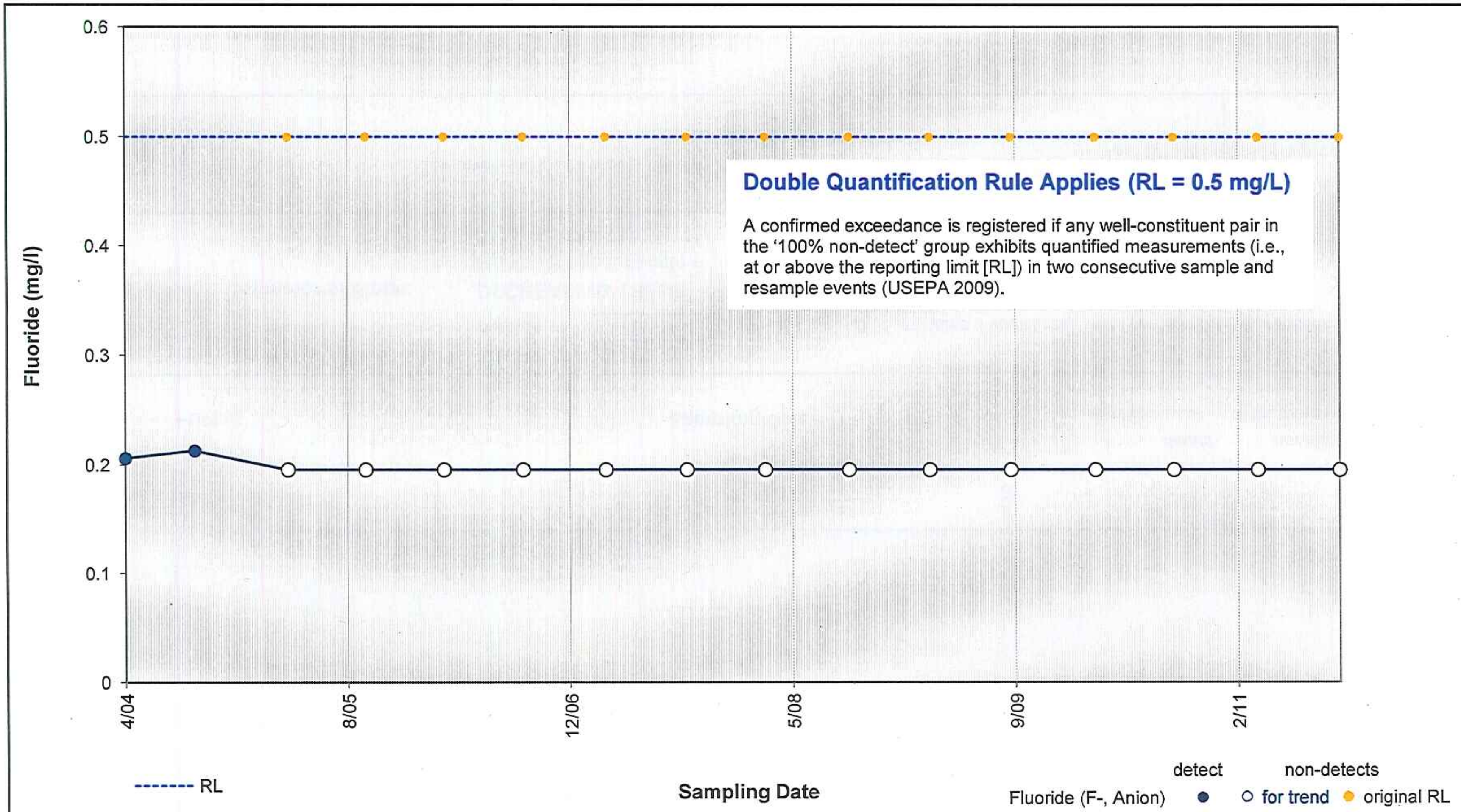
Concentration vs. Time Plot – Cyanide (WAD) in Well MW-36S

LMC - The Dalles

Figure A.13



Results of Mann-Kendall Test for Trend:	**DECREASING TREND**			
	p value =	0.020	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).	
Results of Sen's Estimator of Slope:	**No trend**			
	Median Slope Estimate =	0.0E+00	mg/l Per Day	
	95% Confidence Interval =	0.0E+00	to 0.0E+00	mg/l Per Day

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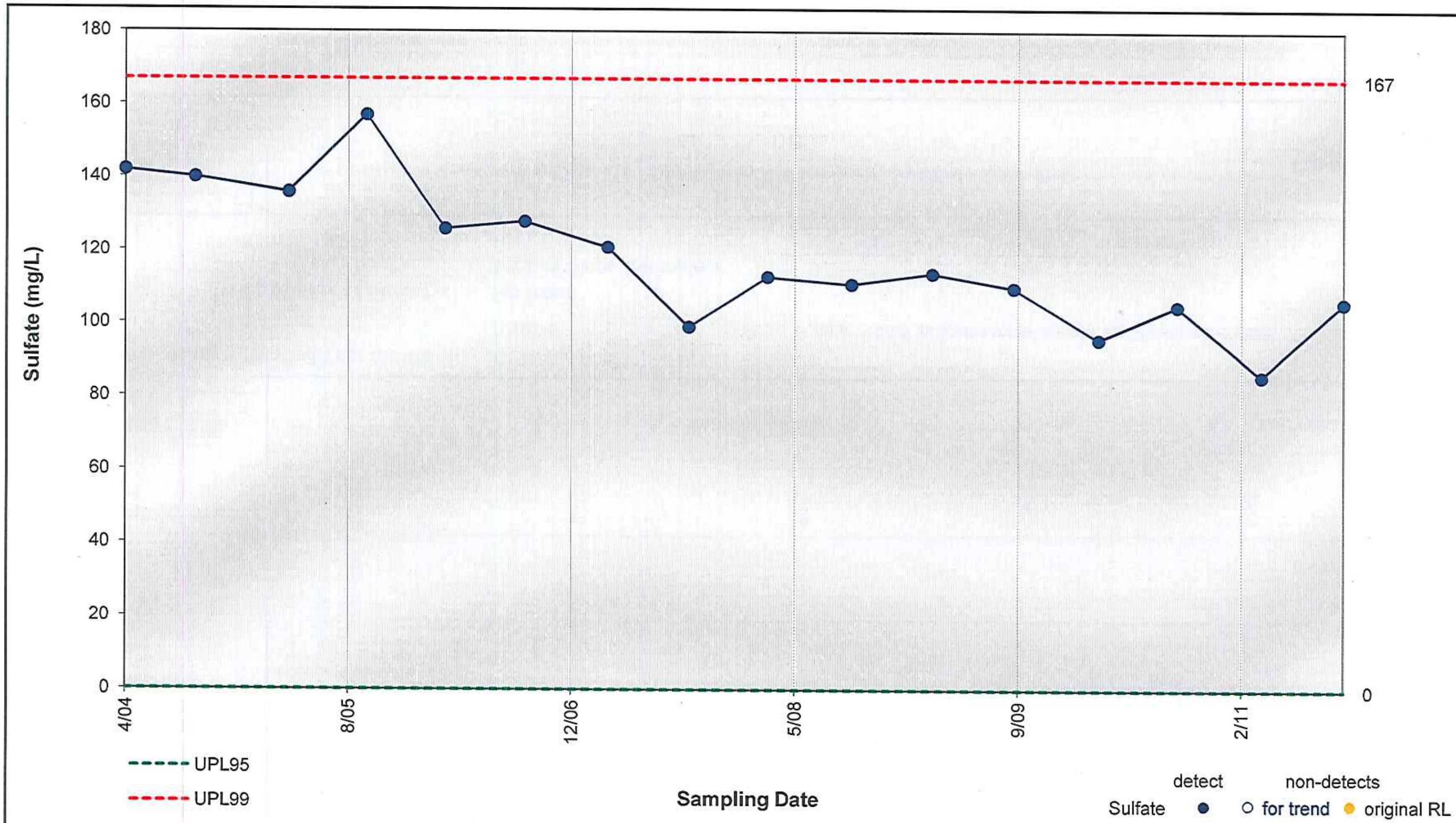
Concentration vs. Time Plot – Fluoride in Well MW-36S

LMC - The Dalles

Figure A.14



Results of Mann-Kendall Test for Trend:	**DECREASING TREND**			
	p value =	<0.001	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).	
Results of Sen's Estimator of Slope:	**DECREASING TREND**			
	Median Slope Estimate =	-1.7E-02	mg/L Per Day	
	95% Confidence Interval =	-2.3E-02	to	-1.3E-02 mg/L Per Day

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Concentration vs. Time Plot – Sulfate in Well MW-36S

LMC - The Dalles

Figure A.15

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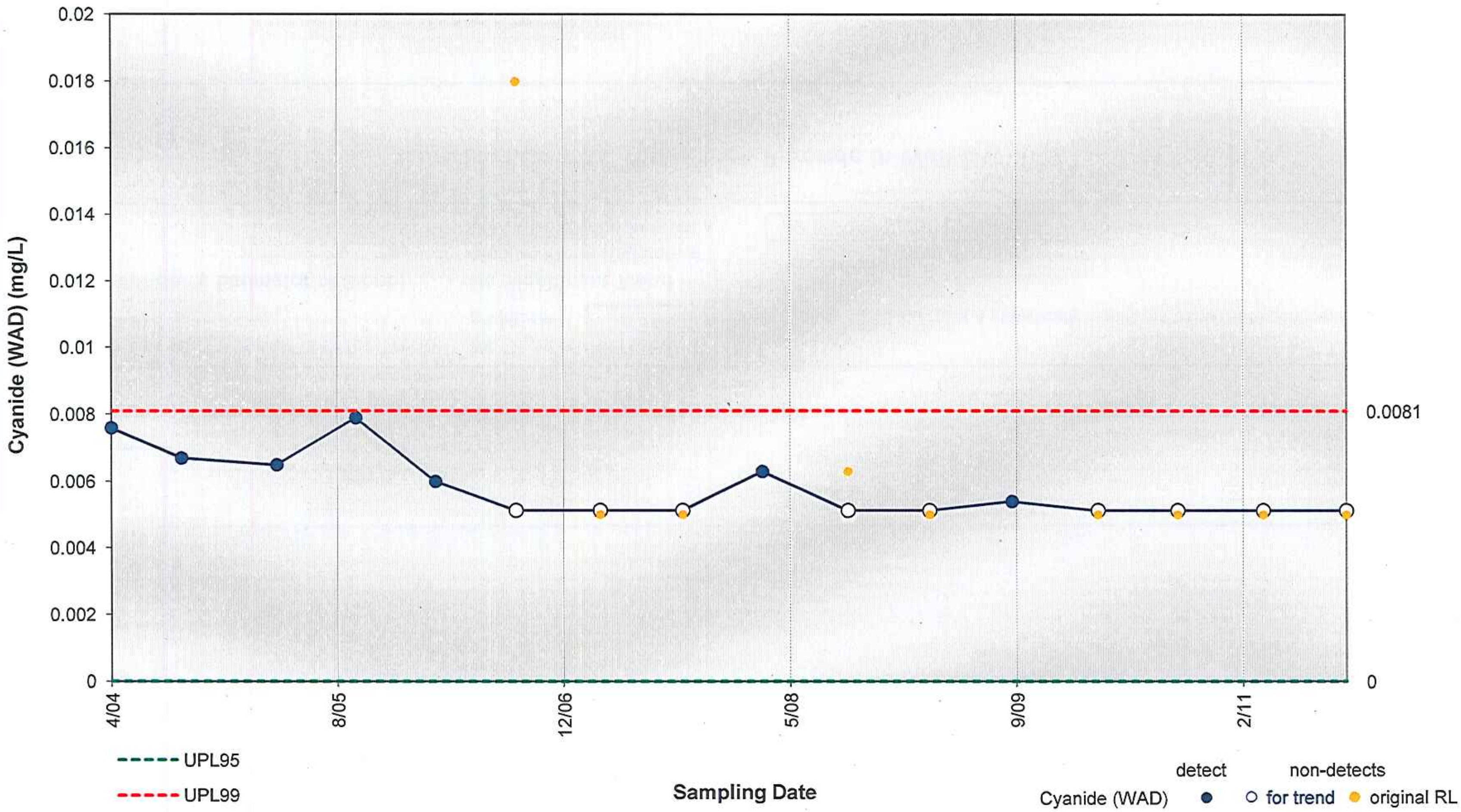

Results of Mann-Kendall Test for Trend: **DECREASING TREND**

p value = 0.002 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **No trend**

Median Slope Estimate = -6.4E-07 mg/L Per Day

95% Confidence Interval = -1.1E-06 to 0.0E+00 mg/L Per Day

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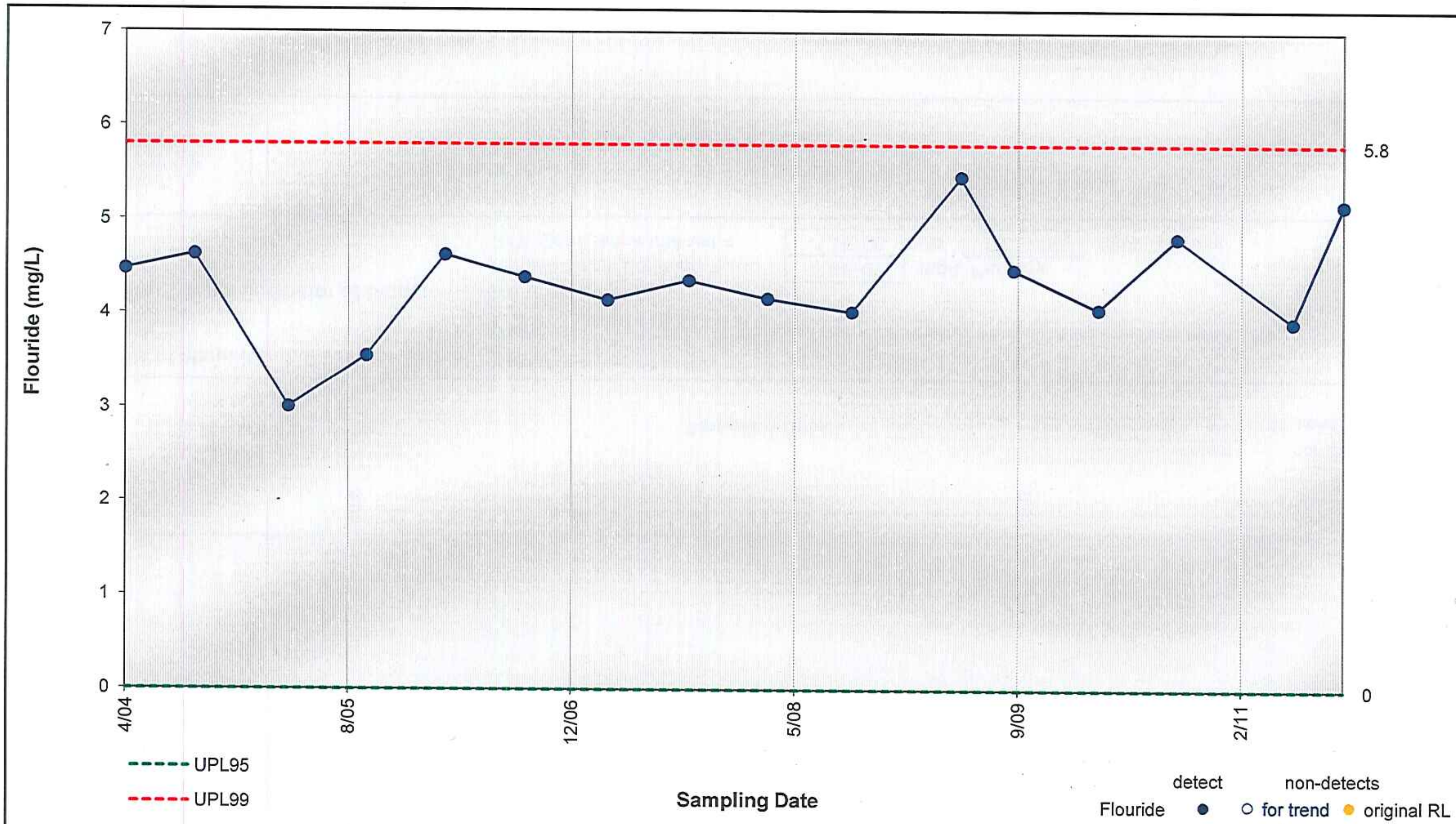
Concentration vs. Time Plot – Cyanide (WAD) in Well MW-37S

LMC - The Dalles

Figure A.16



Results of Mann-Kendall Test for Trend: **No Significant Trend**

p value = 0.294 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **No Significant Trend**

Median Slope Estimate = 1.3E-04 mg/L Per Day

95% Confidence Interval = -2.5E-04 to 6.4E-04 mg/L Per Day

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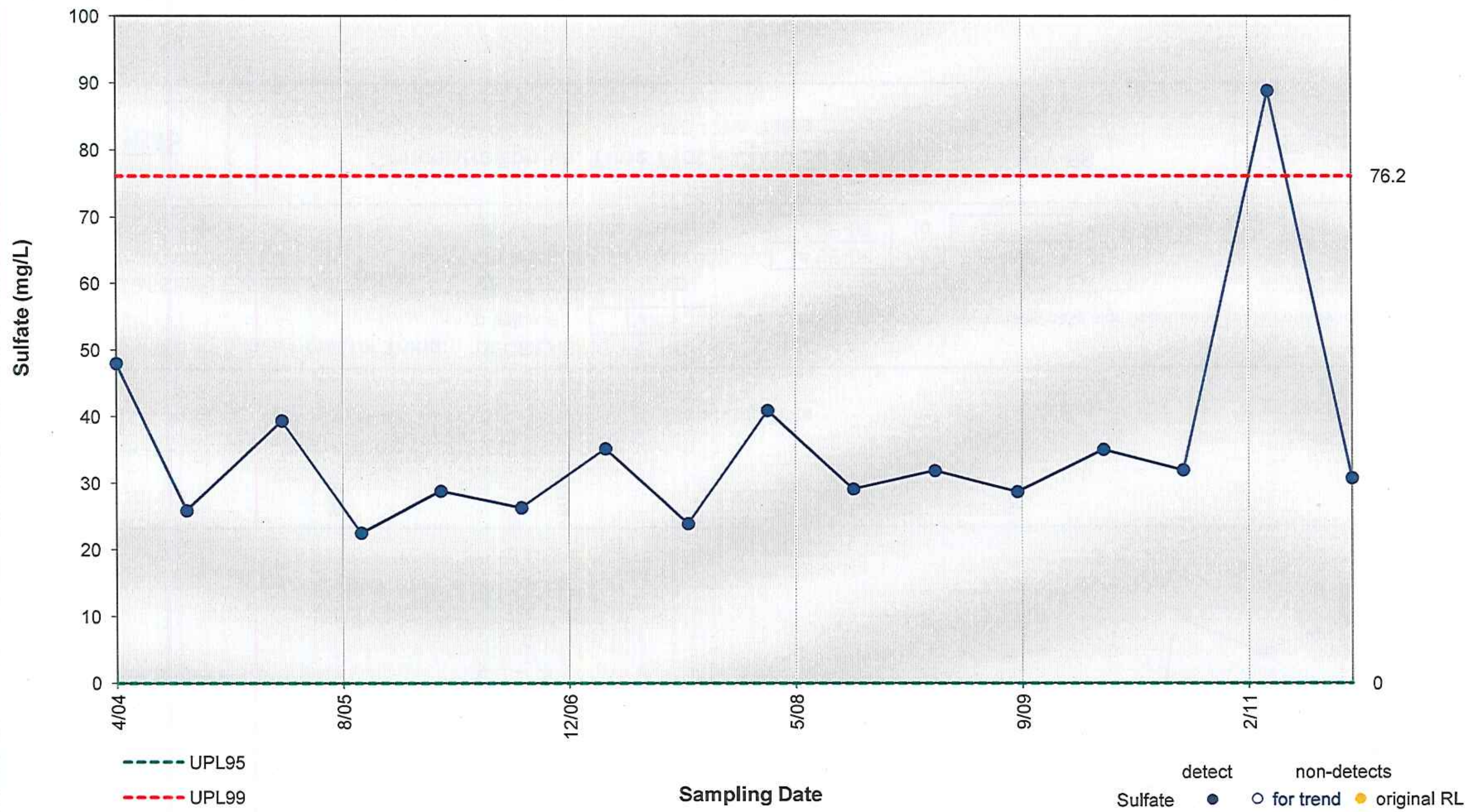
Concentration vs. Time Plot – Fluoride in Well MW-37S

LMC - The Dalles

Figure A.17



Results of Mann-Kendall Test for Trend:	**No Significant Trend**				
	p value =	0.222	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).		
Results of Sen's Estimator of Slope:	**No Significant Trend**				
	Median Slope Estimate =	1.9E-03	mg/L Per Day		
	95% Confidence Interval =	-5.1E-03	to	6.8E-03	mg/L Per Day

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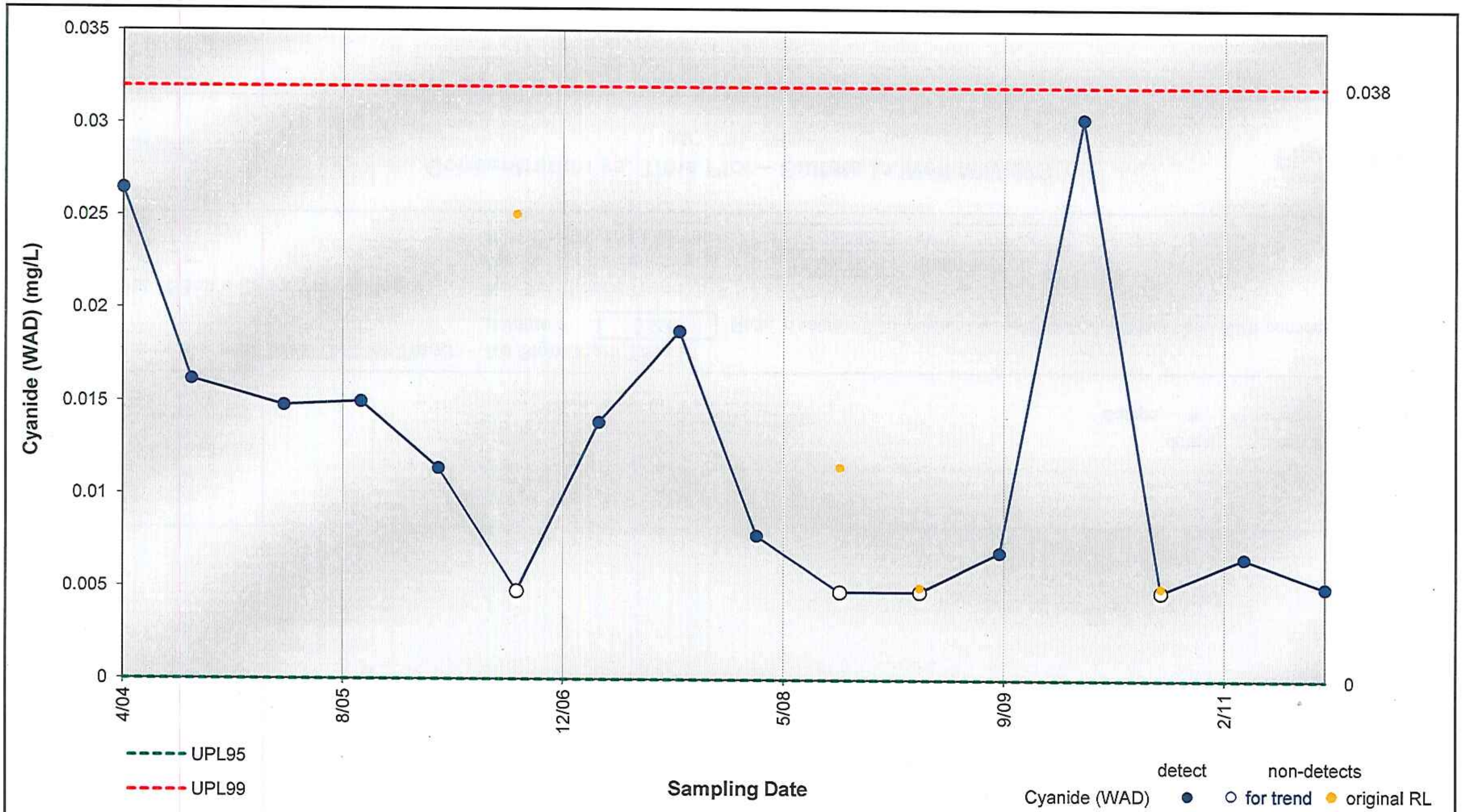
Concentration vs. Time Plot – Sulfate in Well MW-37S

LMC - The Dalles

Figure A.18



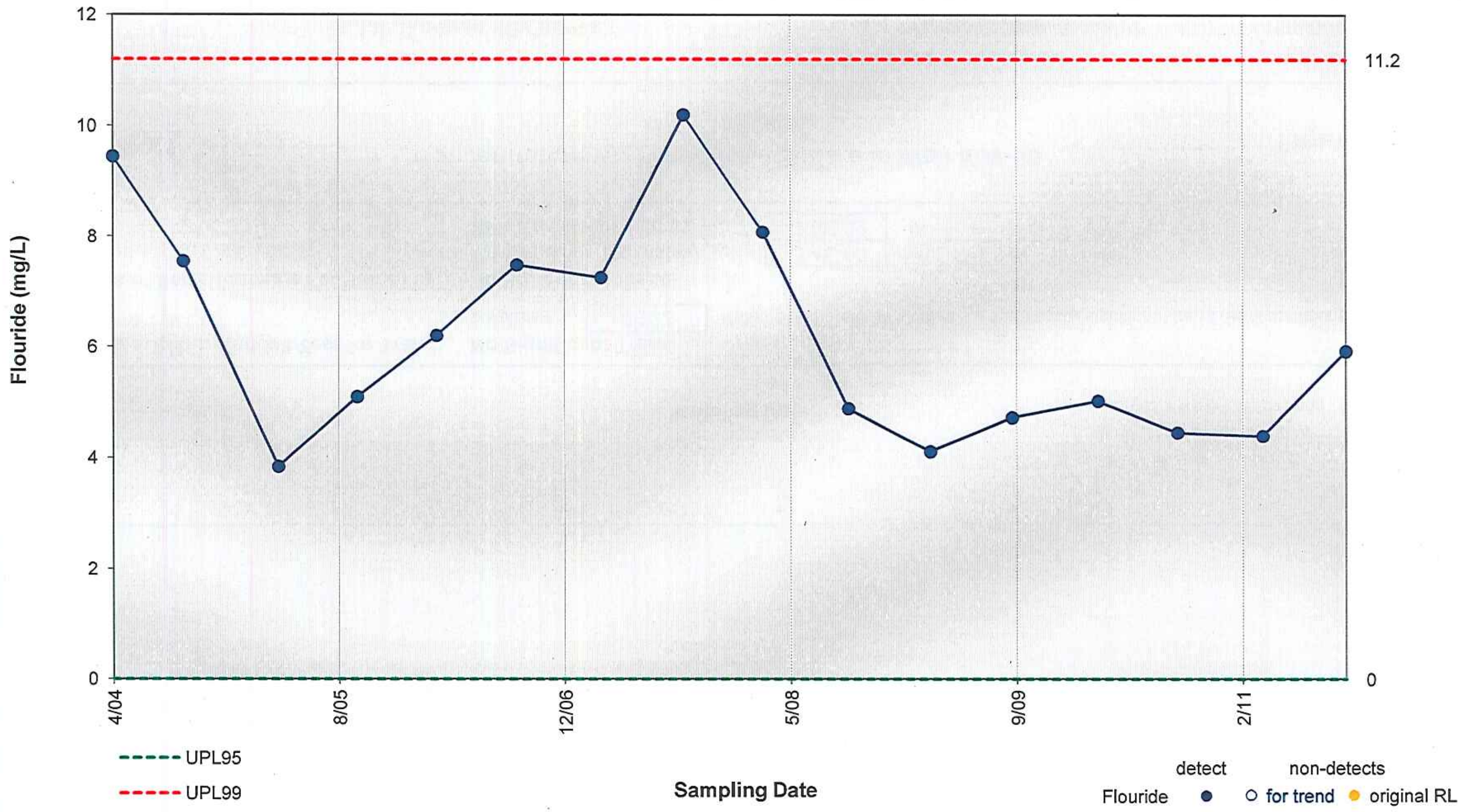
Results of Mann-Kendall Test for Trend:	DECREASING TREND			
	p value =	0.016	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).	
Results of Sen's Estimator of Slope:	DECREASING TREND			
	Median Slope Estimate =	-4.9E-06	mg/L Per Day	
	95% Confidence Interval =	-7.9E-06	to -2.3E-07	mg/L Per Day

ARCADIS

Concentration vs. Time Plot – Cyanide (WAD) in Well MW-5S

LMC - The Dalles

Figure A.19



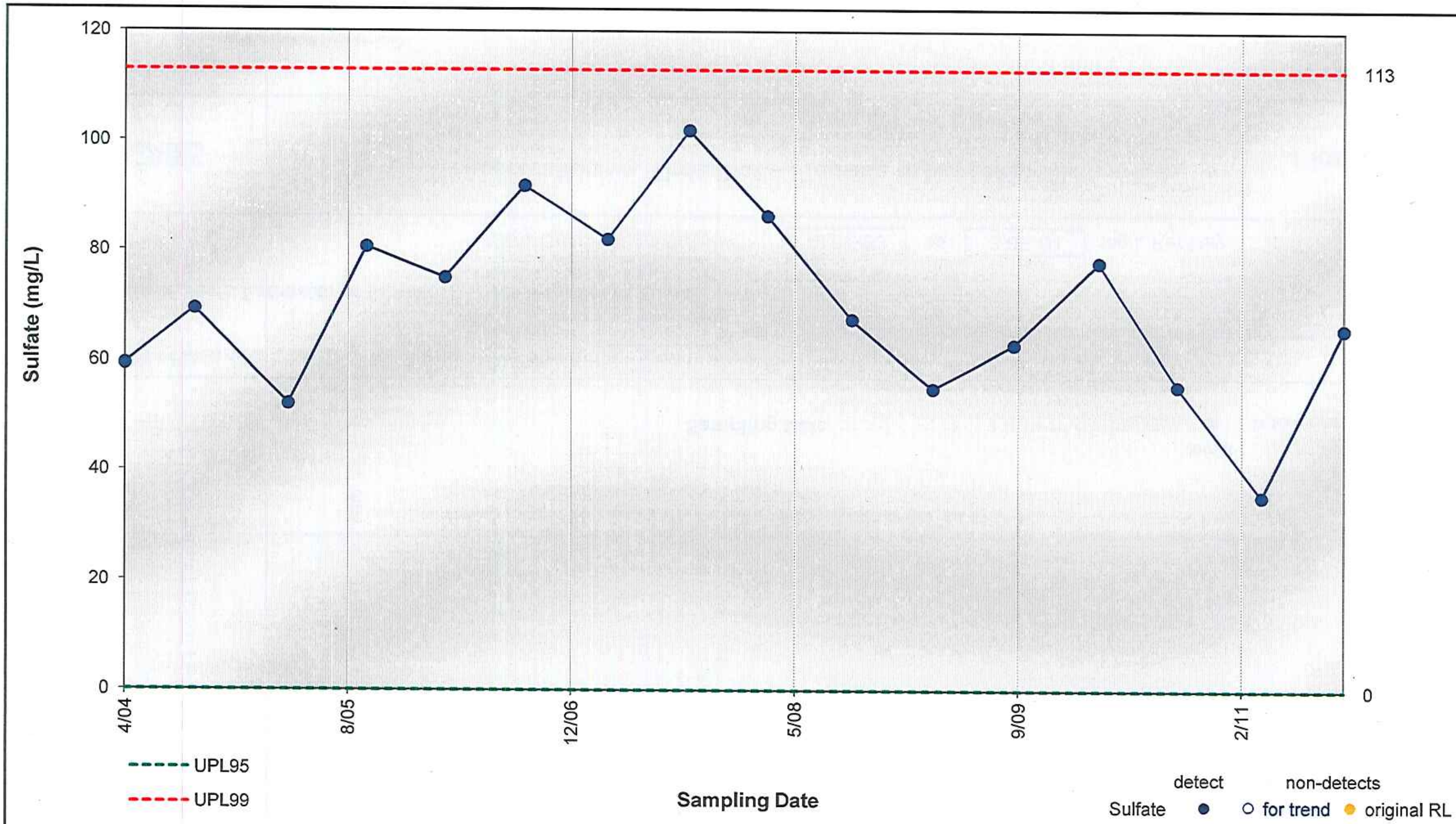
Results of Mann-Kendall Test for Trend: **No Significant Trend**
p value = 0.058 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: **No Significant Trend**
Median Slope Estimate = -8.3E-04 mg/L Per Day
95% Confidence Interval = -2.0E-03 to 3.0E-04 mg/L Per Day

ARCADIS

Concentration vs. Time Plot – Fluoride in Well MW-5S
LMC - The Dalles

Figure A.20



Results of Mann-Kendall Test for Trend:	**No Significant Trend**			
	p value =	0.222	Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).	
Results of Sen's Estimator of Slope:	**No Significant Trend**			
	Median Slope Estimate =	-5.4E-03	mg/L Per Day	
	95% Confidence Interval =	-2.0E-02	to 6.6E-03	mg/L Per Day

ARCADIS

Concentration vs. Time Plot – Sulfate in Well MW-5S

LMC - The Dalles

Figure A.21

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Attachment A.1 Data Used in the Development of Groundwater UPLs at The Dalles.

Sampling Area	Well/Constituent Pair	Date Collected	Order	Result	D_Result	Result Units
LMC The Dalles	MW-5S Cyanide (WAD)	04/05/04	1	0.0265	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	09/08/04	2	0.0162	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	04/06/05	3	0.0148	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	09/28/05	4	0.015	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	03/23/06	5	0.0114	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	09/17/06	6	0.0251	0	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	03/22/07	7	0.0139	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	09/21/07	8	0.0188	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	03/14/08	9	0.0078	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	09/19/08	10	0.0115	0	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	03/19/09	11	0.005	0	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	09/16/09	12	0.0069	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	03/25/10	13	0.0303	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	09/17/10	14	0.005	0	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	03/25/11	15	0.0066	1	mg/L
LMC The Dalles	MW-5S Cyanide (WAD)	09/25/11	16	0.005	1	mg/L
LMC The Dalles	MW-5S Fluoride	04/05/04	1	9.45	1	mg/L
LMC The Dalles	MW-5S Fluoride	09/08/04	2	7.55	1	mg/L
LMC The Dalles	MW-5S Fluoride	04/06/05	3	3.84	1	mg/L
LMC The Dalles	MW-5S Fluoride	09/28/05	4	5.1	1	mg/L
LMC The Dalles	MW-5S Fluoride	03/23/06	5	6.2	1	mg/L
LMC The Dalles	MW-5S Fluoride	09/17/06	6	7.48	1	mg/L
LMC The Dalles	MW-5S Fluoride	03/22/07	7	7.25	1	mg/L
LMC The Dalles	MW-5S Fluoride	09/21/07	8	10.2	1	mg/L
LMC The Dalles	MW-5S Fluoride	03/14/08	9	8.08	1	mg/L
LMC The Dalles	MW-5S Fluoride	09/19/08	10	4.89	1	mg/L
LMC The Dalles	MW-5S Fluoride	03/19/09	11	4.11	1	mg/L
LMC The Dalles	MW-5S Fluoride	09/16/09	12	4.73	1	mg/L
LMC The Dalles	MW-5S Fluoride	03/25/10	13	5.03	1	mg/L
LMC The Dalles	MW-5S Fluoride	09/17/10	14	4.46	1	mg/L
LMC The Dalles	MW-5S Fluoride	03/25/11	15	4.4	1	mg/L
LMC The Dalles	MW-5S Fluoride	09/25/11	16	5.92	1	mg/L
LMC The Dalles	MW-5S Sulfate	04/05/04	1	59.4	1	mg/L
LMC The Dalles	MW-5S Sulfate	09/08/04	2	69.4	1	mg/L
LMC The Dalles	MW-5S Sulfate	04/06/05	3	52.1	1	mg/L
LMC The Dalles	MW-5S Sulfate	09/28/05	4	80.7	1	mg/L
LMC The Dalles	MW-5S Sulfate	03/23/06	5	75.1	1	mg/L
LMC The Dalles	MW-5S Sulfate	09/17/06	6	91.9	1	mg/L
LMC The Dalles	MW-5S Sulfate	03/22/07	7	82.1	1	mg/L
LMC The Dalles	MW-5S Sulfate	09/21/07	8	102	1	mg/L
LMC The Dalles	MW-5S Sulfate	03/14/08	9	86.4	1	mg/L
LMC The Dalles	MW-5S Sulfate	09/19/08	10	67.6	1	mg/L
LMC The Dalles	MW-5S Sulfate	03/19/09	11	55	1	mg/L
LMC The Dalles	MW-5S Sulfate	09/16/09	12	63	1	mg/L
LMC The Dalles	MW-5S Sulfate	03/25/10	13	78	1	mg/L
LMC The Dalles	MW-5S Sulfate	09/17/10	14	55.5	1	mg/L
LMC The Dalles	MW-5S Sulfate	03/25/11	15	35.4	1	mg/L
LMC The Dalles	MW-5S Sulfate	09/25/11	16	65.9	1	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	04/05/04	1	0.0071	1	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	09/07/04	2	0.0064	1	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	04/06/05	3	0.0063	1	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	09/28/05	4	0.0056	1	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	03/23/06	5	0.0061	1	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	09/17/06	6	0.005	0	mg/L

Attachment A.1 Data Used in the Development of Groundwater UPLs at The Dalles.

Sampling Area	Well/Constituent Pair	Date Collected	Order	Result	D_Result	Result Units
LMC The Dalles	MW-17S Cyanide (WAD)	03/22/07	7	0.005	0	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	09/20/07	8	0.005	0	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	03/14/08	9	0.025	0	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	09/18/08	10	0.0059	0	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	03/18/09	11	0.005	0	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	09/16/09	12	0.005	0	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	03/25/10	13	0.005	0	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	09/17/10	14	0.005	0	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	03/25/11	15	0.005	0	mg/L
LMC The Dalles	MW-17S Cyanide (WAD)	09/25/11	16	0.005	0	mg/L
LMC The Dalles	MW-17S Fluoride	04/05/04	1	0.626	1	mg/L
LMC The Dalles	MW-17S Fluoride	09/07/04	2	0.733	1	mg/L
LMC The Dalles	MW-17S Fluoride	04/06/05	3	0.5	0	mg/L
LMC The Dalles	MW-17S Fluoride	09/28/05	4	0.64	1	mg/L
LMC The Dalles	MW-17S Fluoride	03/23/06	5	0.5	0	mg/L
LMC The Dalles	MW-17S Fluoride	09/17/06	6	0.66	1	mg/L
LMC The Dalles	MW-17S Fluoride	03/22/07	7	0.72	1	mg/L
LMC The Dalles	MW-17S Fluoride	09/20/07	8	0.7	1	mg/L
LMC The Dalles	MW-17S Fluoride	03/14/08	9	0.5	0	mg/L
LMC The Dalles	MW-17S Fluoride	09/18/08	10	0.67	1	mg/L
LMC The Dalles	MW-17S Fluoride	03/18/09	11	0.5	0	mg/L
LMC The Dalles	MW-17S Fluoride	09/16/09	12	0.51	1	mg/L
LMC The Dalles	MW-17S Fluoride	03/25/10	13	0.5	0	mg/L
LMC The Dalles	MW-17S Fluoride	09/17/10	14	0.55	1	mg/L
LMC The Dalles	MW-17S Fluoride	03/25/11	15	0.5	0	mg/L
LMC The Dalles	MW-17S Fluoride	09/25/11	16	0.54	1	mg/L
LMC The Dalles	MW-17S Sulfate	04/05/04	1	61.4	1	mg/L
LMC The Dalles	MW-17S Sulfate	09/07/04	2	62.2	1	mg/L
LMC The Dalles	MW-17S Sulfate	04/06/05	3	60.6	1	mg/L
LMC The Dalles	MW-17S Sulfate	09/28/05	4	61.3	1	mg/L
LMC The Dalles	MW-17S Sulfate	03/23/06	5	59.5	1	mg/L
LMC The Dalles	MW-17S Sulfate	09/17/06	6	62.6	1	mg/L
LMC The Dalles	MW-17S Sulfate	03/22/07	7	56.8	1	mg/L
LMC The Dalles	MW-17S Sulfate	09/20/07	8	60.3	1	mg/L
LMC The Dalles	MW-17S Sulfate	03/14/08	9	56.6	1	mg/L
LMC The Dalles	MW-17S Sulfate	09/18/08	10	58.2	1	mg/L
LMC The Dalles	MW-17S Sulfate	03/18/09	11	50.4	1	mg/L
LMC The Dalles	MW-17S Sulfate	09/16/09	12	53.4	1	mg/L
LMC The Dalles	MW-17S Sulfate	03/25/10	13	52	1	mg/L
LMC The Dalles	MW-17S Sulfate	09/17/10	14	48.4	1	mg/L
LMC The Dalles	MW-17S Sulfate	03/25/11	15	46.8	1	mg/L
LMC The Dalles	MW-17S Sulfate	09/25/11	16	44.7	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	04/05/04	1	0.0231	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	09/08/04	2	0.0249	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	04/06/05	3	0.0366	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	09/28/05	4	0.0194	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	03/23/06	5	0.0406	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	09/17/06	6	0.036	0	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	03/22/07	7	0.011	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	09/21/07	8	0.0102	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	03/14/08	9	0.0231	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	09/19/08	10	0.0244	0	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	03/19/09	11	0.0235	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	09/16/09	12	0.0208	1	mg/L

Attachment A.1 Data Used in the Development of Groundwater UPLs at The Dalles.

Sampling Area	Well/Constituent Pair	Date Collected	Order	Result	D_Result	Result Units
LMC The Dalles	MW-22S Cyanide (WAD)	03/25/10	13	0.0199	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	09/17/10	14	0.0076	1	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	03/25/11	15	0.005	0	mg/L
LMC The Dalles	MW-22S Cyanide (WAD)	09/25/11	16	0.006	1	mg/L
LMC The Dalles	MW-22S Fluoride	04/05/04	1	0.479	1	mg/L
LMC The Dalles	MW-22S Fluoride	09/08/04	2	0.504	1	mg/L
LMC The Dalles	MW-22S Fluoride	04/06/05	3	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	09/28/05	4	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	03/23/06	5	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	09/17/06	6	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	03/22/07	7	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	09/21/07	8	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	03/14/08	9	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	09/19/08	10	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	03/19/09	11	0.528	1	mg/L
LMC The Dalles	MW-22S Fluoride	09/16/09	12	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	03/25/10	13	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	09/17/10	14	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	03/25/11	15	0.5	0	mg/L
LMC The Dalles	MW-22S Fluoride	09/25/11	16	0.5	0	mg/L
LMC The Dalles	MW-22S Sulfate	04/05/04	1	69.8	1	mg/L
LMC The Dalles	MW-22S Sulfate	09/08/04	2	64.1	1	mg/L
LMC The Dalles	MW-22S Sulfate	04/06/05	3	63.8	1	mg/L
LMC The Dalles	MW-22S Sulfate	09/28/05	4	57.7	1	mg/L
LMC The Dalles	MW-22S Sulfate	03/23/06	5	71.6	1	mg/L
LMC The Dalles	MW-22S Sulfate	09/17/06	6	65.4	1	mg/L
LMC The Dalles	MW-22S Sulfate	03/22/07	7	68.3	1	mg/L
LMC The Dalles	MW-22S Sulfate	09/21/07	8	55.9	1	mg/L
LMC The Dalles	MW-22S Sulfate	03/14/08	9	68.9	1	mg/L
LMC The Dalles	MW-22S Sulfate	09/19/08	10	86.1	1	mg/L
LMC The Dalles	MW-22S Sulfate	03/19/09	11	84.2	1	mg/L
LMC The Dalles	MW-22S Sulfate	09/16/09	12	91.1	1	mg/L
LMC The Dalles	MW-22S Sulfate	03/25/10	13	89.1	1	mg/L
LMC The Dalles	MW-22S Sulfate	09/17/10	14	97.4	1	mg/L
LMC The Dalles	MW-22S Sulfate	03/25/11	15	89.7	1	mg/L
LMC The Dalles	MW-22S Sulfate	09/25/11	16	104	1	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	04/05/04	1	0.0102	1	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	09/07/04	2	0.0097	1	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	04/06/05	3	0.0119	1	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	09/28/05	4	0.0078	1	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	03/23/06	5	0.0125	1	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	09/18/06	6	0.0104	0	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	03/22/07	7	0.005	0	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	09/20/07	8	0.005	0	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	03/14/08	9	0.025	0	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	09/19/08	10	0.0093	0	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	03/19/09	11	0.005	0	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	09/16/09	12	0.005	0	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	03/25/10	13	0.0058	1	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	09/17/10	14	0.005	0	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	03/25/11	15	0.005	0	mg/L
LMC The Dalles	MW-23S Cyanide (WAD)	09/25/11	16	0.005	0	mg/L
LMC The Dalles	MW-23S Fluoride	04/05/04	1	0.234	1	mg/L
LMC The Dalles	MW-23S Fluoride	09/07/04	2	0.253	1	mg/L

Attachment A.1 Data Used in the Development of Groundwater UPLs at The Dalles.

Sampling Area	Well/Constituent Pair	Date Collected	Order	Result	D_Result	Result Units
LMC The Dalles	MW-23S Fluoride	04/06/05	3	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	09/28/05	4	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	03/23/06	5	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	09/18/06	6	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	03/22/07	7	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	09/20/07	8	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	03/14/08	9	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	09/19/08	10	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	03/19/09	11	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	09/16/09	12	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	03/25/10	13	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	09/17/10	14	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	03/25/11	15	0.5	0	mg/L
LMC The Dalles	MW-23S Fluoride	09/25/11	16	0.5	0	mg/L
LMC The Dalles	MW-23S Sulfate	04/05/04	1	51.5	1	mg/L
LMC The Dalles	MW-23S Sulfate	09/07/04	2	53.1	1	mg/L
LMC The Dalles	MW-23S Sulfate	04/06/05	3	53.6	1	mg/L
LMC The Dalles	MW-23S Sulfate	09/28/05	4	50.5	1	mg/L
LMC The Dalles	MW-23S Sulfate	03/23/06	5	51.8	1	mg/L
LMC The Dalles	MW-23S Sulfate	09/18/06	6	51	1	mg/L
LMC The Dalles	MW-23S Sulfate	03/22/07	7	47	1	mg/L
LMC The Dalles	MW-23S Sulfate	09/20/07	8	47.8	1	mg/L
LMC The Dalles	MW-23S Sulfate	03/14/08	9	44.8	1	mg/L
LMC The Dalles	MW-23S Sulfate	09/19/08	10	46.9	1	mg/L
LMC The Dalles	MW-23S Sulfate	03/19/09	11	43.6	1	mg/L
LMC The Dalles	MW-23S Sulfate	09/16/09	12	45.7	1	mg/L
LMC The Dalles	MW-23S Sulfate	03/25/10	13	44.4	1	mg/L
LMC The Dalles	MW-23S Sulfate	09/17/10	14	41	1	mg/L
LMC The Dalles	MW-23S Sulfate	03/25/11	15	42.7	1	mg/L
LMC The Dalles	MW-23S Sulfate	09/25/11	16	29.7	1	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	04/05/04	1	0.0084	1	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	09/07/04	2	0.0067	1	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	04/06/05	3	0.0112	1	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	09/28/05	4	0.006	1	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	03/23/06	5	0.0068	1	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	09/17/06	6	0.0076	0	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	03/22/07	7	0.005	1	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	09/20/07	8	0.005	0	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	03/14/08	9	0.025	0	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	09/18/08	10	0.0095	0	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	03/18/09	11	0.005	0	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	09/16/09	12	0.0053	1	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	03/25/10	13	0.005	0	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	09/17/10	14	0.005	0	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	03/25/11	15	0.005	0	mg/L
LMC The Dalles	MW-35S Cyanide (WAD)	09/25/11	16	0.005	0	mg/L
LMC The Dalles	MW-35S Fluoride	04/05/04	1	0.868	1	mg/L
LMC The Dalles	MW-35S Fluoride	09/07/04	2	0.949	1	mg/L
LMC The Dalles	MW-35S Fluoride	04/06/05	3	0.6	1	mg/L
LMC The Dalles	MW-35S Fluoride	09/28/05	4	0.64	1	mg/L
LMC The Dalles	MW-35S Fluoride	03/23/06	5	0.69	1	mg/L
LMC The Dalles	MW-35S Fluoride	09/17/06	6	0.66	1	mg/L
LMC The Dalles	MW-35S Fluoride	03/22/07	7	0.61	1	mg/L
LMC The Dalles	MW-35S Fluoride	09/20/07	8	0.64	1	mg/L

Attachment A.1 Data Used in the Development of Groundwater UPLs at The Dalles.

Sampling Area	Well/Constituent Pair	Date Collected	Order	Result	D_Result	Result Units
LMC The Dalles	MW-35S Fluoride	03/14/08	9	0.64	1	mg/L
LMC The Dalles	MW-35S Fluoride	09/18/08	10	0.65	1	mg/L
LMC The Dalles	MW-35S Fluoride	03/18/09	11	0.698	1	mg/L
LMC The Dalles	MW-35S Fluoride	09/16/09	12	0.53	1	mg/L
LMC The Dalles	MW-35S Fluoride	03/25/10	13	0.59	1	mg/L
LMC The Dalles	MW-35S Fluoride	09/17/10	14	0.6	1	mg/L
LMC The Dalles	MW-35S Fluoride	03/25/11	15	0.54	1	mg/L
LMC The Dalles	MW-35S Fluoride	09/25/11	16	0.64	1	mg/L
LMC The Dalles	MW-35S Sulfate	04/05/04	1	127	1	mg/L
LMC The Dalles	MW-35S Sulfate	09/07/04	2	129	1	mg/L
LMC The Dalles	MW-35S Sulfate	04/06/05	3	123	1	mg/L
LMC The Dalles	MW-35S Sulfate	09/28/05	4	125	1	mg/L
LMC The Dalles	MW-35S Sulfate	03/23/06	5	120	1	mg/L
LMC The Dalles	MW-35S Sulfate	09/17/06	6	118	1	mg/L
LMC The Dalles	MW-35S Sulfate	03/22/07	7	119	1	mg/L
LMC The Dalles	MW-35S Sulfate	09/20/07	8	114	1	mg/L
LMC The Dalles	MW-35S Sulfate	03/14/08	9	117	1	mg/L
LMC The Dalles	MW-35S Sulfate	09/18/08	10	119	1	mg/L
LMC The Dalles	MW-35S Sulfate	03/18/09	11	116	1	mg/L
LMC The Dalles	MW-35S Sulfate	09/16/09	12	111	1	mg/L
LMC The Dalles	MW-35S Sulfate	03/25/10	13	110	1	mg/L
LMC The Dalles	MW-35S Sulfate	09/17/10	14	109	1	mg/L
LMC The Dalles	MW-35S Sulfate	03/25/11	15	112	1	mg/L
LMC The Dalles	MW-35S Sulfate	09/25/11	16	110	1	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	04/05/04	1	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	09/08/04	2	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	04/06/05	3	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	09/28/05	4	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	03/23/06	5	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	09/17/06	6	0.0193	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	03/22/07	7	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	09/20/07	8	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	03/14/08	9	0.025	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	09/18/08	10	0.007	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	03/18/09	11	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	09/16/09	12	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	03/25/10	13	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	09/17/10	14	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	03/25/11	15	0.005	0	mg/L
LMC The Dalles	MW-36S Cyanide (WAD)	09/25/11	16	0.005	0	mg/L
LMC The Dalles	MW-36S Fluoride	04/05/04	1	0.206	1	mg/L
LMC The Dalles	MW-36S Fluoride	09/08/04	2	0.213	1	mg/L
LMC The Dalles	MW-36S Fluoride	04/06/05	3	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	09/28/05	4	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	03/23/06	5	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	09/17/06	6	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	03/22/07	7	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	09/20/07	8	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	03/14/08	9	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	09/18/08	10	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	03/18/09	11	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	09/16/09	12	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	03/25/10	13	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	09/17/10	14	0.5	0	mg/L

Attachment A.1 Data Used in the Development of Groundwater UPLs at The Dalles.

Sampling Area	Well/Constituent Pair	Date Collected	Order	Result	D_Result	Result Units
LMC The Dalles	MW-36S Fluoride	03/25/11	15	0.5	0	mg/L
LMC The Dalles	MW-36S Fluoride	09/25/11	16	0.5	0	mg/L
LMC The Dalles	MW-36S Sulfate	04/05/04	1	142	1	mg/L
LMC The Dalles	MW-36S Sulfate	09/08/04	2	140	1	mg/L
LMC The Dalles	MW-36S Sulfate	04/06/05	3	136	1	mg/L
LMC The Dalles	MW-36S Sulfate	09/28/05	4	157	1	mg/L
LMC The Dalles	MW-36S Sulfate	03/23/06	5	126	1	mg/L
LMC The Dalles	MW-36S Sulfate	09/17/06	6	128	1	mg/L
LMC The Dalles	MW-36S Sulfate	03/22/07	7	121	1	mg/L
LMC The Dalles	MW-36S Sulfate	09/20/07	8	99.1	1	mg/L
LMC The Dalles	MW-36S Sulfate	03/14/08	9	113	1	mg/L
LMC The Dalles	MW-36S Sulfate	09/18/08	10	111	1	mg/L
LMC The Dalles	MW-36S Sulfate	03/18/09	11	114	1	mg/L
LMC The Dalles	MW-36S Sulfate	09/16/09	12	110	1	mg/L
LMC The Dalles	MW-36S Sulfate	03/25/10	13	95.8	1	mg/L
LMC The Dalles	MW-36S Sulfate	09/17/10	14	105	1	mg/L
LMC The Dalles	MW-36S Sulfate	03/25/11	15	85.9	1	mg/L
LMC The Dalles	MW-36S Sulfate	09/25/11	16	106	1	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	04/05/04	1	0.0076	1	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	09/07/04	2	0.0067	1	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	04/06/05	3	0.0065	1	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	09/28/05	4	0.0079	1	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	03/23/06	5	0.006	1	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	09/17/06	6	0.018	0	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	03/22/07	7	0.005	0	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	09/20/07	8	0.005	0	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	03/14/08	9	0.0063	1	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	09/19/08	10	0.0063	0	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	03/18/09	11	0.005	0	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	09/16/09	12	0.0054	1	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	03/25/10	13	0.005	0	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	09/17/10	14	0.005	0	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	03/25/11	15	0.005	0	mg/L
LMC The Dalles	MW-37S Cyanide (WAD)	09/25/11	16	0.005	0	mg/L
LMC The Dalles	MW-37S Fluoride	04/05/04	1	4.47	1	mg/L
LMC The Dalles	MW-37S Fluoride	09/07/04	2	4.63	1	mg/L
LMC The Dalles	MW-37S Fluoride	04/06/05	3	3.01	1	mg/L
LMC The Dalles	MW-37S Fluoride	09/28/05	4	3.55	1	mg/L
LMC The Dalles	MW-37S Fluoride	03/23/06	5	4.63	1	mg/L
LMC The Dalles	MW-37S Fluoride	09/17/06	6	4.39	1	mg/L
LMC The Dalles	MW-37S Fluoride	03/22/07	7	4.15	1	mg/L
LMC The Dalles	MW-37S Fluoride	09/20/07	8	4.36	1	mg/L
LMC The Dalles	MW-37S Fluoride	03/14/08	9	4.17	1	mg/L
LMC The Dalles	MW-37S Fluoride	09/19/08	10	4.03	1	mg/L
LMC The Dalles	MW-37S Fluoride	05/21/09	11	5.47	1	mg/L
LMC The Dalles	MW-37S Fluoride	09/16/09	12	4.48	1	mg/L
LMC The Dalles	MW-37S Fluoride	03/25/10	13	4.06	1	mg/L
LMC The Dalles	MW-37S Fluoride	09/17/10	14	4.82	1	mg/L
LMC The Dalles	MW-37S Fluoride	06/04/11	15	3.92	1	mg/L
LMC The Dalles	MW-37S Fluoride	09/25/11	16	5.17	1	mg/L
LMC The Dalles	MW-37S Sulfate	04/05/04	1	48	1	mg/L
LMC The Dalles	MW-37S Sulfate	09/07/04	2	25.9	1	mg/L
LMC The Dalles	MW-37S Sulfate	04/06/05	3	39.4	1	mg/L
LMC The Dalles	MW-37S Sulfate	09/28/05	4	22.5	1	mg/L

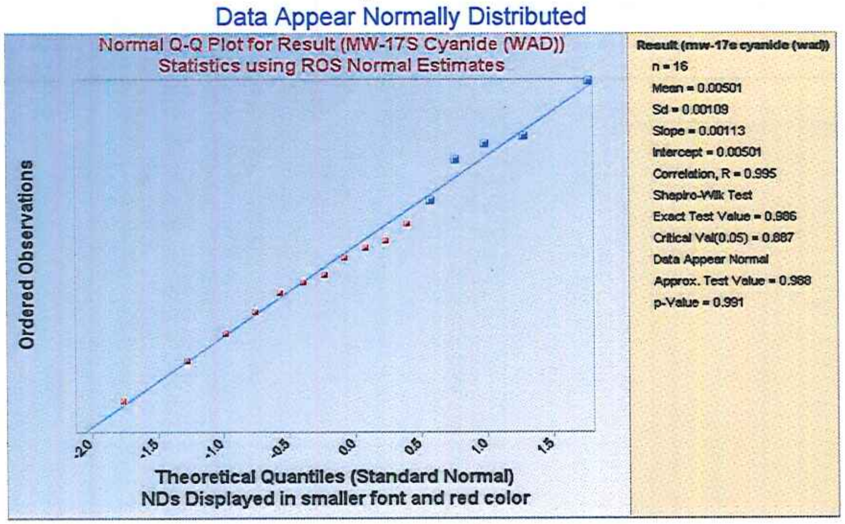
Attachment A.1 Data Used in the Development of Groundwater UPLs at The Dalles.

Sampling Area	Well/Constituent Pair	Date Collected	Order	Result	D_Result	Result Units
LMC The Dalles	MW-37S Sulfate	03/23/06	5	28.8	1	mg/L
LMC The Dalles	MW-37S Sulfate	09/17/06	6	26.3	1	mg/L
LMC The Dalles	MW-37S Sulfate	03/22/07	7	35.2	1	mg/L
LMC The Dalles	MW-37S Sulfate	09/20/07	8	23.9	1	mg/L
LMC The Dalles	MW-37S Sulfate	03/14/08	9	40.9	1	mg/L
LMC The Dalles	MW-37S Sulfate	09/19/08	10	29.1	1	mg/L
LMC The Dalles	MW-37S Sulfate	03/18/09	11	31.9	1	mg/L
LMC The Dalles	MW-37S Sulfate	09/16/09	12	28.7	1	mg/L
LMC The Dalles	MW-37S Sulfate	03/25/10	13	35.1	1	mg/L
LMC The Dalles	MW-37S Sulfate	09/17/10	14	32	1	mg/L
LMC The Dalles	MW-37S Sulfate	03/25/11	15	88.9	1	mg/L
LMC The Dalles	MW-37S Sulfate	09/25/11	16	30.8	1	mg/L

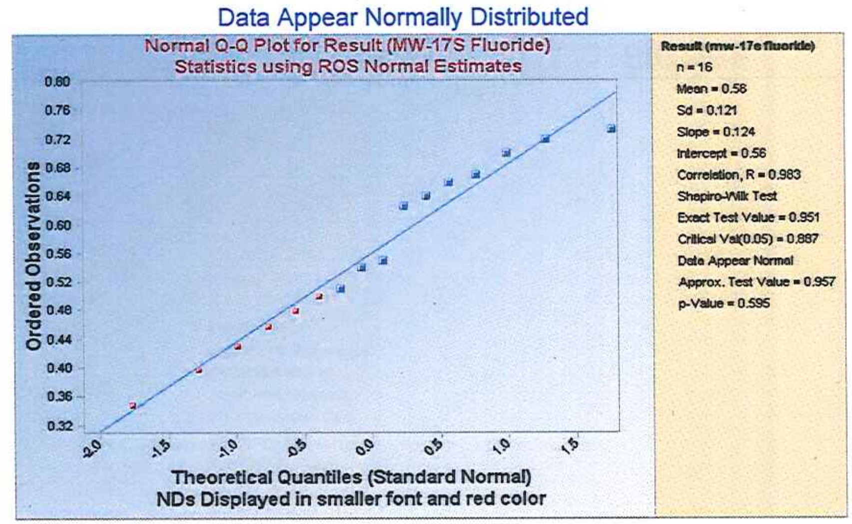
ARCADIS

Attachment B

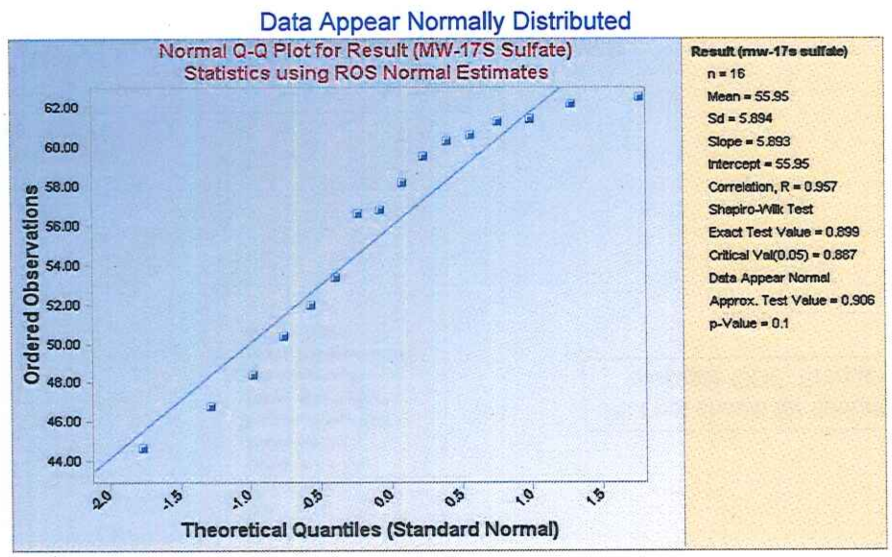
Cyanide



Fluoride



Sulfate



ARCADIS

Quantile plots for the most recent 16 samples in MW-17S

FIGURE B.1

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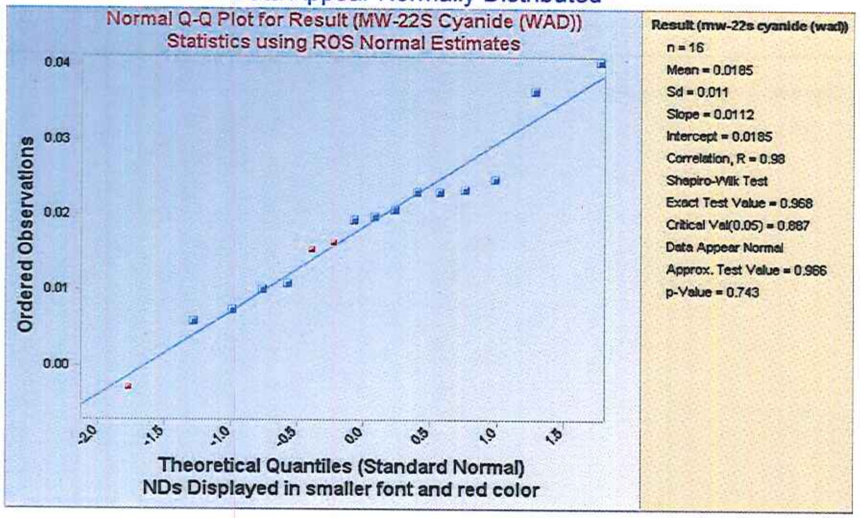
Cyanide

Data Appear Normally Distributed



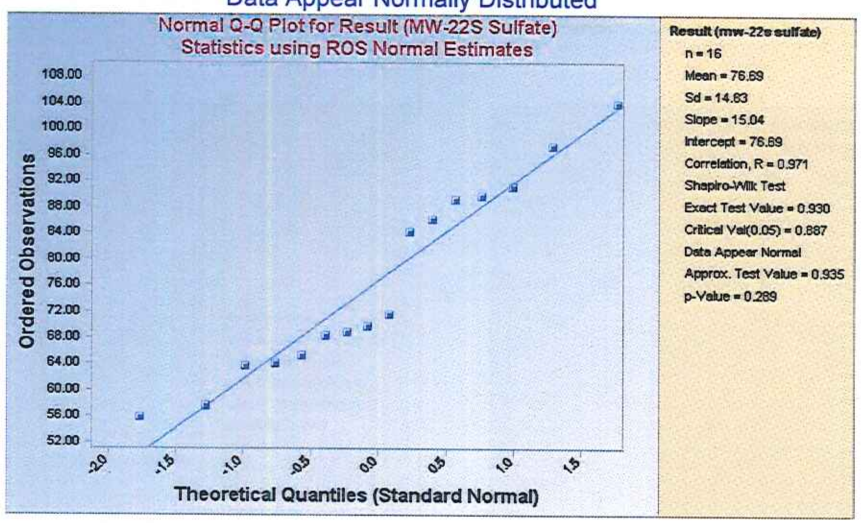
Fluoride

NA

Plot not shown for fluoride. Insufficient # of detects to evaluate GOF. Frequency of detection = 3 of 16.

Sulfate

Data Appear Normally Distributed



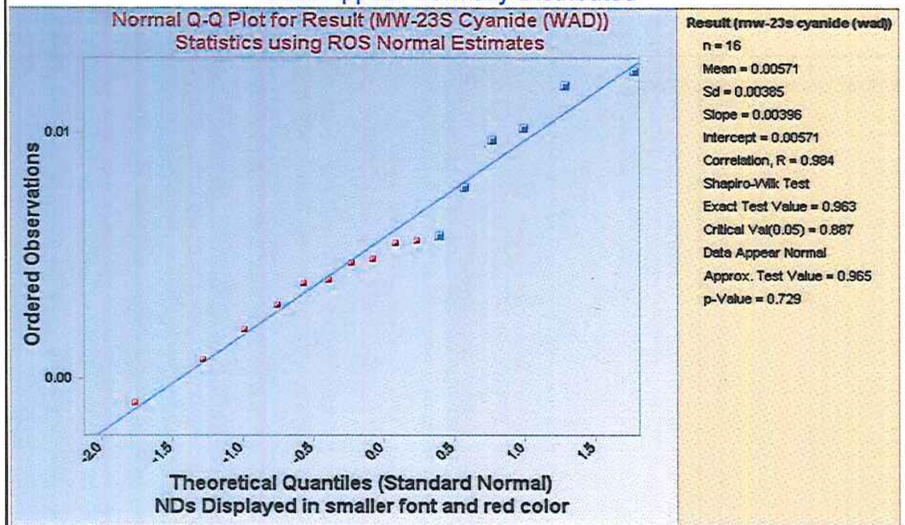
ARCADIS

Quantile plots for the most recent 16 samples in MW-22S

FIGURE B.2

Cyanide

Data Appear Normally Distributed



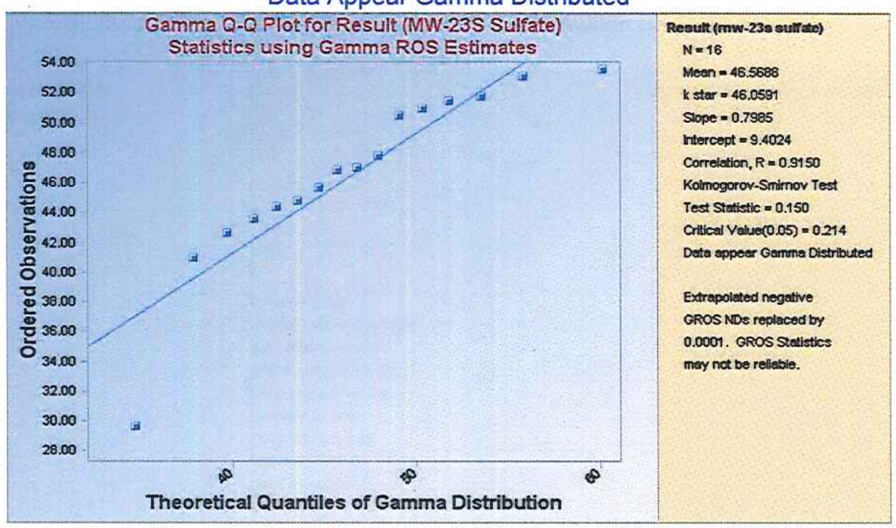
Fluoride

NA

Plot not shown for fluoride. Insufficient # of detects to evaluate GOF. Frequency of detection = 2 of 16.

Sulfate

Data Appear Gamma Distributed



ARCADIS	Quantile plots for the most recent 16 samples in MW-23S	FIGURE B.3

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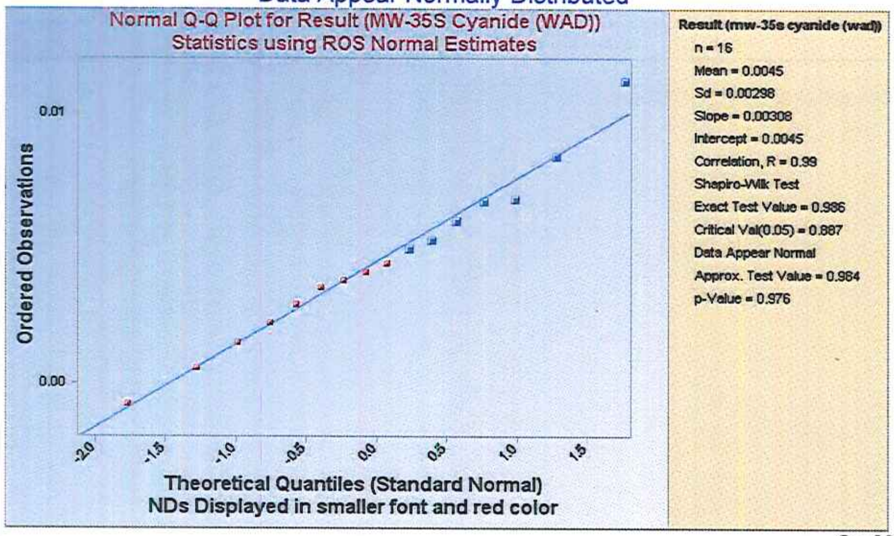
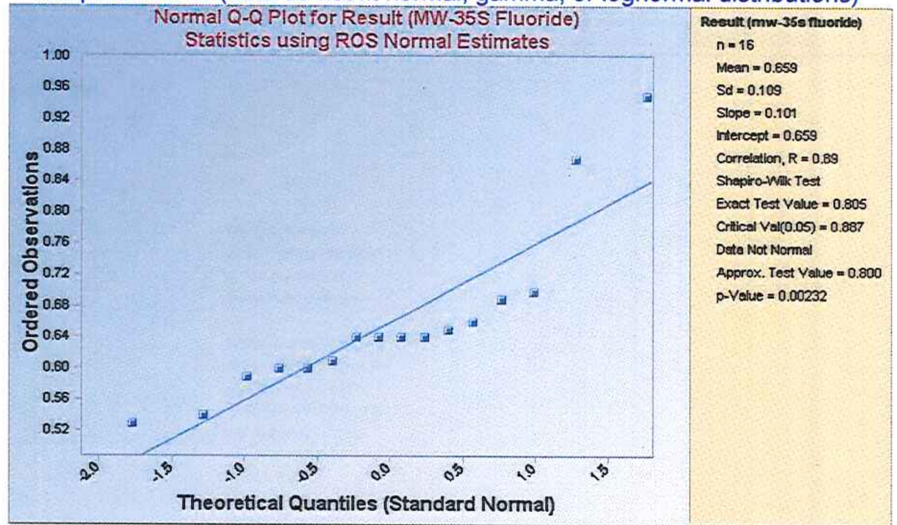
Cyanide

Data Appear Normally Distributed



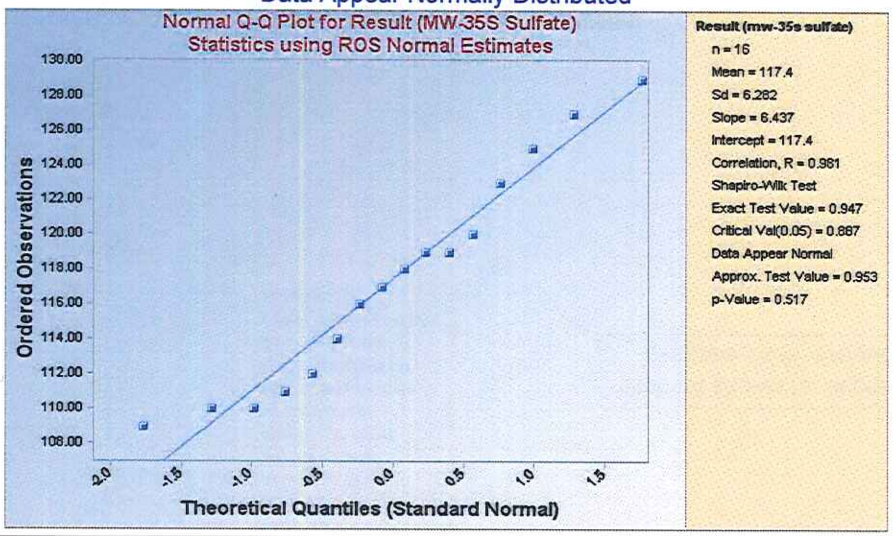
Fluoride

Nonparameteric (data do not fit normal, gamma, or lognormal distributions)



Sulfate

Data Appear Normally Distributed



ARCADIS	Quantile plots for the most recent 16 samples in MW-35S	FIGURE B.4

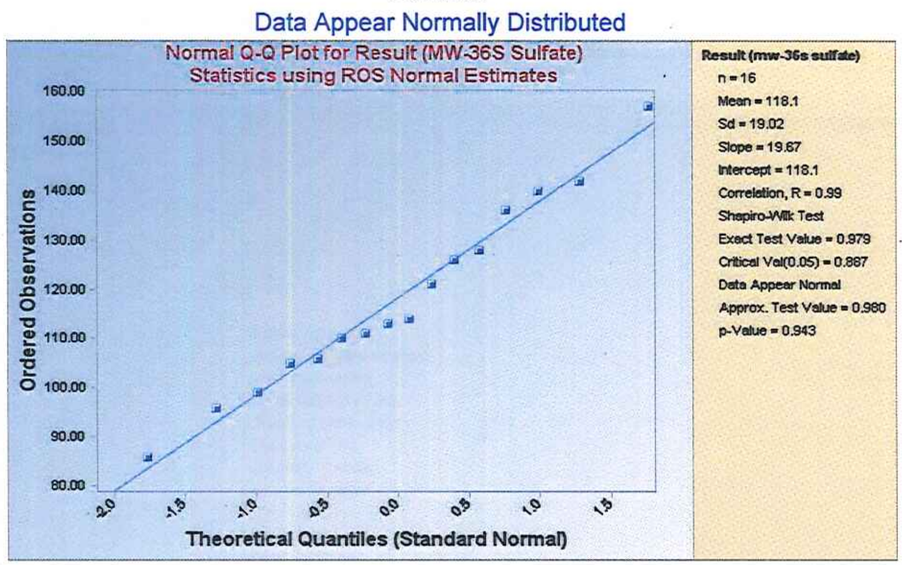
Cyanide
NA

Plot not shown for cyanide. Insufficient # of detects to evaluate GOF. Frequency of detection = 0 of 16.

Fluoride
NA

Plot not shown for fluoride. Insufficient # of detects to evaluate GOF. Frequency of detection = 2 of 16.

Sulfate



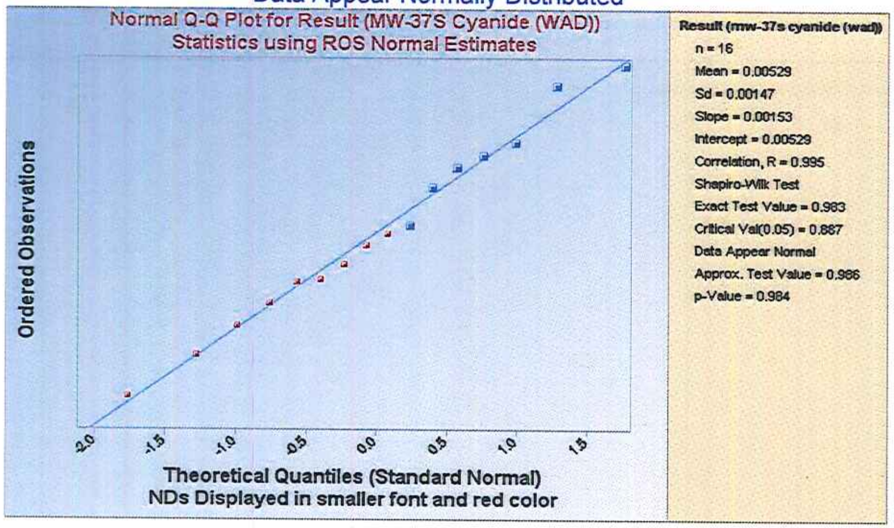
ARCADIS

Quantile plots for the most recent 16 samples in MW-36S

FIGURE B.5

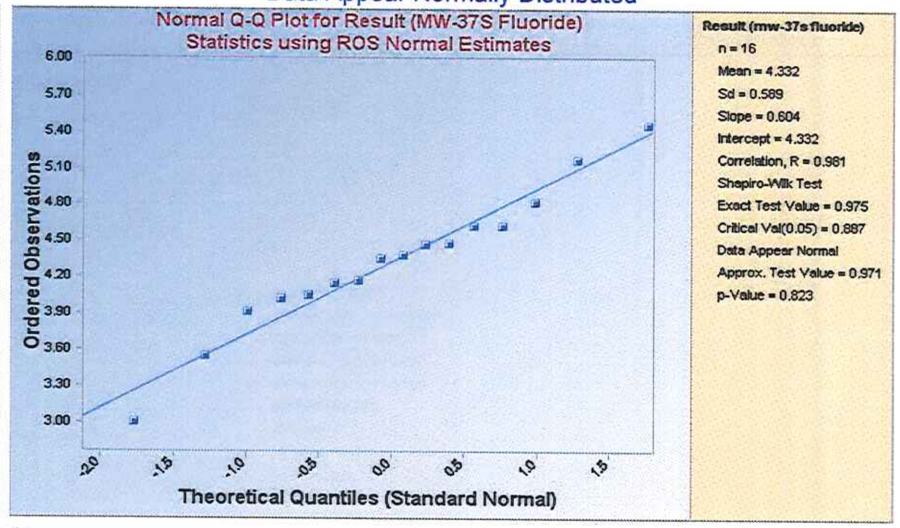
Cyanide

Data Appear Normally Distributed



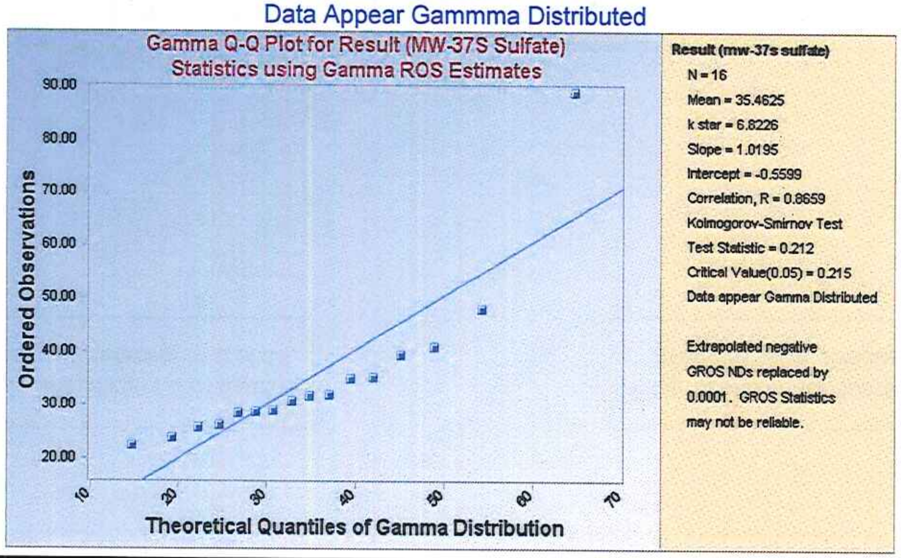
Fluoride

Data Appear Normally Distributed



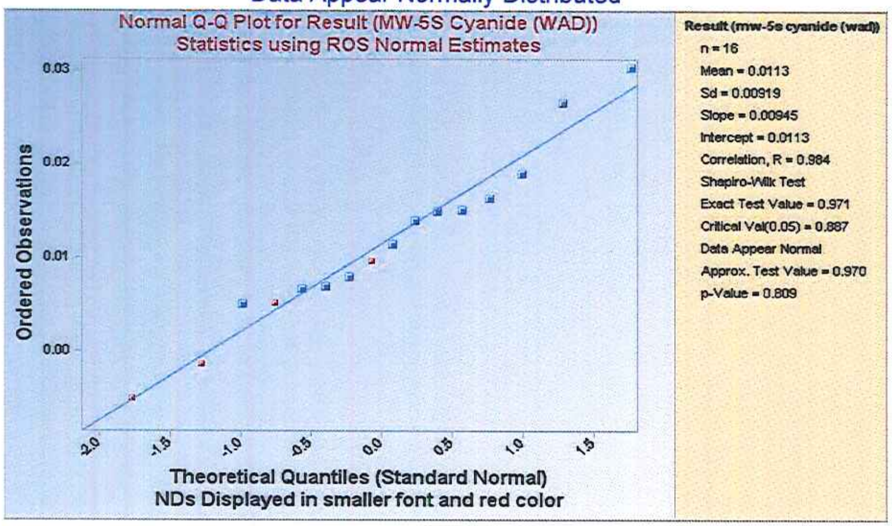
Sulfate

Data Appear Gammma Distributed

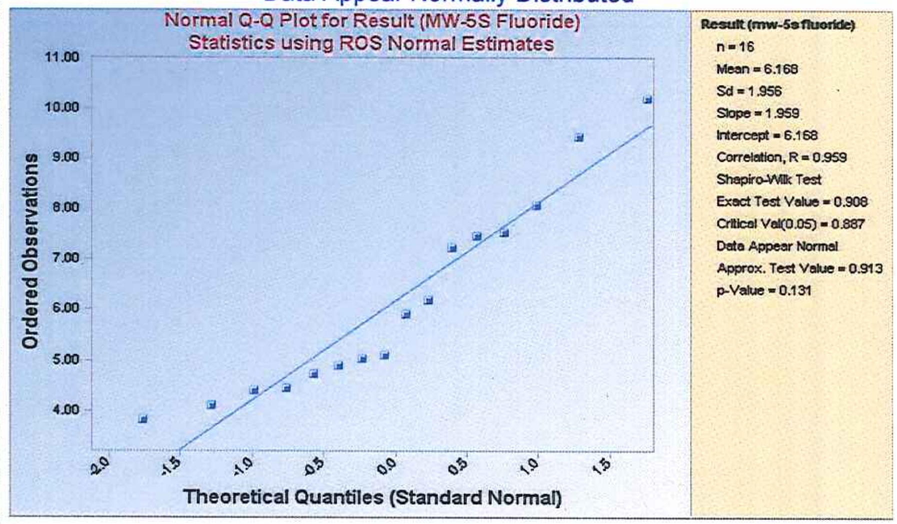


ARCADIS	Quantile plots for the most recent 16 samples in MW-37S	FIGURE B.6

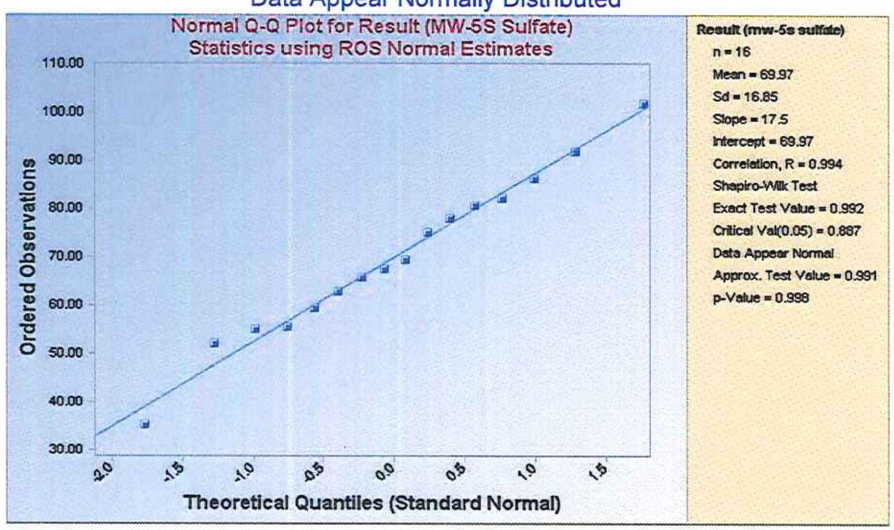
Cyanide



Fluoride



Sulfate



ARCADIS	Quantile plots for the most recent 16 samples in MW-5S	FIGURE B.7

requirements, *there is an increased potential for release from the unit.* Furthermore, the current permit states "[B]ecause the current bottom liner is less protective than what the regulations currently require, the Department issues this Permit considering that any detected contamination above the groundwater protection standard is likely from the landfill which leads this Permit to more straightforwardly report the analytical results … and more forward with notification and analysis …."

The language of the Statement of Basis and draft permit represent a significant shift in DEQ's conclusions. EPA disagrees with the groundwater monitoring approach found in the draft permit, as noted in our comments of May 2011 and further discussed below. At a minimum, the language found in the Statement of Basis indicating that groundwater "may" have no beneficial use must be deleted in its entirety, as it has no relevance to developing a robust detection monitoring program for the RCRA landfill.

17. Page 36, Section IV.C, Monitoring Constituents. As no changes were made to this section of the permit, EPA is repeating its comment of May 2011. Since this permit begins a new statistical test, four observations or sampling events may not be sufficient for a valid statistical analysis. EPA's Unified Guidance (Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, EPA/530/R-09/007, 2009) recommends that a minimum of at least 8 to 10 independent background observations be collected before running most statistical tests. It is recommended at a minimum that quarterly sampling be conducted for two years and then semi-annually for the last two years as long as there are no seasonal effects. This would be important if a decision is made to use an interwell approach.

18. Page 37, Section IV.C.2. As no changes were made to this section of the permit, EPA is repeating its comment of May 2011. This permit condition requires the Permittees to reevaluate each monitoring well's upper prediction limits for each constituent "using appropriate EPA and statistical guidance." If the intent of this permit condition is to require the Permittees to reevaluate using EPA's Unified Guidance, this must be stated directly. The permit must be revised to specify what method and/or assumptions must be used in the reevaluation.

19. Page 38, Section IV.F, Detection Monitoring Limits and Definitions to Indicate a Significant Statistical Increase. As no changes were made to this section of the permit, EPA is repeating its comment of May 2011. The draft permit proposes comparing data from each individual monitoring well to historical data from that same well (intrawell) using the Upper Prediction Limits statistical test. This proposal is not consistent with the intent of this statistical test, as it is designed to compare data between wells (interwell). MW-5S is an up-gradient monitoring well location, but appears to have higher concentrations of weak acid dissociable (WAD) cyanide, fluoride and sulfate than the monitoring wells located down-gradient of the regulated landfill. This may be why the

draft permit proposes to conduct intrawell comparisons, as it would be hard to compare the results using an interwell approach in this situation. Given the higher up-gradient contaminant concentrations, a different statistical test such as the Shewhart-CUSUM control charts may be a better choice. Alternatively, if additional monitoring wells are installed upgradient of the RCRA landfill and found to be free of contaminants (we recommend at least one and perhaps two new upgradient wells would be appropriate), then an interwell approach for the statistical test could be used.

20. Page 46, Section V.C.5. EPA appreciates inclusion of the specific reference to the design plans and operating practices for the run-on and run-off collection facilities at the landfill. However, as discussed in EPA's comment of May 2011, these design plans and operating practices must be included as an attachment to this permit.

21. Page 46, Section V.C.6. This new permit condition states that the Permittees may use a vacuum system at the landfill to provide ambient carbon dioxide to lessen the cyanide toxicity and to dry the landfill mass to lessen the hydraulic head. The draft permit must be revised to specify all applicable operating parameters and restrictions (such as no uncontrolled venting). The Attachments to the draft permit must also be revised to incorporate this system into the inspection program, training plan, contingency plan, and post-closure cost estimate, and to include as-built drawings of the system and all operating procedures.

22. Page 47, Section V.E. EPA recommends further revising this new section to state only that the leachate tank is a unit subject to the generator requirements of 40 CFR §261.5 and 40 CFR Part 262, rather than stating the unit is a "conditionally exempt generator" tank. As discussed above, this wording will result in robust, enforceable permit language without the administrative burden of permit modification if leachate production increases during the term of this permit.

23. Figure 2, RCRA Landfill Showing Location of Monitoring Wells. As revised Figures were not provided with the March 2012 draft permit, EPA is repeating its comment of May 2011. It would be helpful if this figure included the most recent groundwater elevation as an example, and graphics showing the groundwater flow direction.

24. Attachment A, Inspection Plan. As revised Attachments were not provided with the March 2012 draft permit, EPA is repeating its comment of May 2011. The permit must be revised to include the procedure for the "Quarterly Wet Test" of the leak alarm and high level included on the RCRA Landfill Post-Closure Care Leachate Collection System Inspection Form.

MOORE Fredrick

From: Negley, Timothy [Timothy.Negley@arcadis-us.com]
Sent: Wednesday, July 13, 2011 10:53 AM
To: MOORE Fredrick
Cc: Cole, Connie
Subject: FW: Power Curves
Attachments: Power curve comparison.pdf

Hi Frederick,

Please see feedback from Sanitas below. I have attached the power curves you and I calculated. We should be using annual sampling as per the first graph I initially set up.

Does that clear it up?

Tim

Timothy Negley | Senior Environmental Scientist | timothy.negley@arcadis-us.com | T. 315.671.9569

-----Original Message-----
From: Kristina Rayner [mailto:kristina@sanitastech.com]
Sent: Wednesday, July 13, 2011 1:31 PM
To: Negley, Timothy
Cc: 'Pat Campbell'
Subject: RE: Power Curves

Thank you, that was very helpful to see the graphs. It appears that the difference is actually in the set-up window of Options\Configure Sanitas\Prediction Limit Tab where Sanitas asks you to specify the number of sampling events per year, wells, constituents, etc. The first graph that you sent has a kappa value consistent with an annual sampling schedule (i.e.
"1" event per year), whereas the second graph is consistent with semi-annual sampling (i.e. "2" events per year). So depending on which sample schedule you are on, that information would need to be entered in that window. I hope that helps, but please let me know if you have any other questions.

Sincerely,

Kristina Rayner
Sanitas Technologies
22052 W. 66th Street, Ste. 133
Shawnee, KS 66226
Phone: 913-829-1470
Fax: 831-854-1470
kristina@sanitastech.com

-----Original Message-----
From: Negley, Timothy [mailto:Timothy.Negley@arcadis-us.com]
Sent: Wednesday, July 13, 2011 10:49 AM
To: Kristina Rayner
Subject: RE: Power Curves

Thank you for looking into it Kristina. I have attached a pdf of the inputs and outputs for the two versions. The alpha value is 0.01.

Feel free to call me with questions.

Thanks!
Tim

Timothy Negley | Senior Environmental Scientist | timothy.negley@arcadis-us.com | T. 315.671.9569

-----Original Message-----
From: Kristina Rayner [mailto:kristina@sanitastech.com]
Sent: Wednesday, July 13, 2011 11:40 AM
To: Negley, Timothy
Subject: FW: Power Curves

Good Morning,

The power curves should not have changed between those two versions, so maybe if I could see a .pdf of the two curves that are different, it would help me figure out what could have changed. I don't have the ability to provide an older version of the demo software once a new version is released, and we are currently on v9.2. Please feel free to email your graphs though and I'll assist with that. Thanks!

Kristina Rayner
Sanitas Technologies
22052 W. 66th Street, Ste. 133
Shawnee, KS 66226
Phone: 913-829-1470
Fax: 831-854-1470
kristina@sanitastech.com

-----Original Message-----
From: pat@sanitastech.com [mailto:pat@sanitastech.com]
Sent: Tuesday, July 12, 2011 6:08 PM
To: kristina@sanitastech.com
Subject: web posting

name= Tim Negley
email= timothy.negley@arcadis-us.com
telephone= 315.671.9569
title=
company= ARCADIS

address=
city=
state=
zip=
country=
comments= I am trying to reproduce an analysis completed with sanitas demo version 9.1.21. Has the power curve algorithms changed between that version and version 9.2.10? Can I obtain another download for the previous 9.1.21?
Thank you for your time.

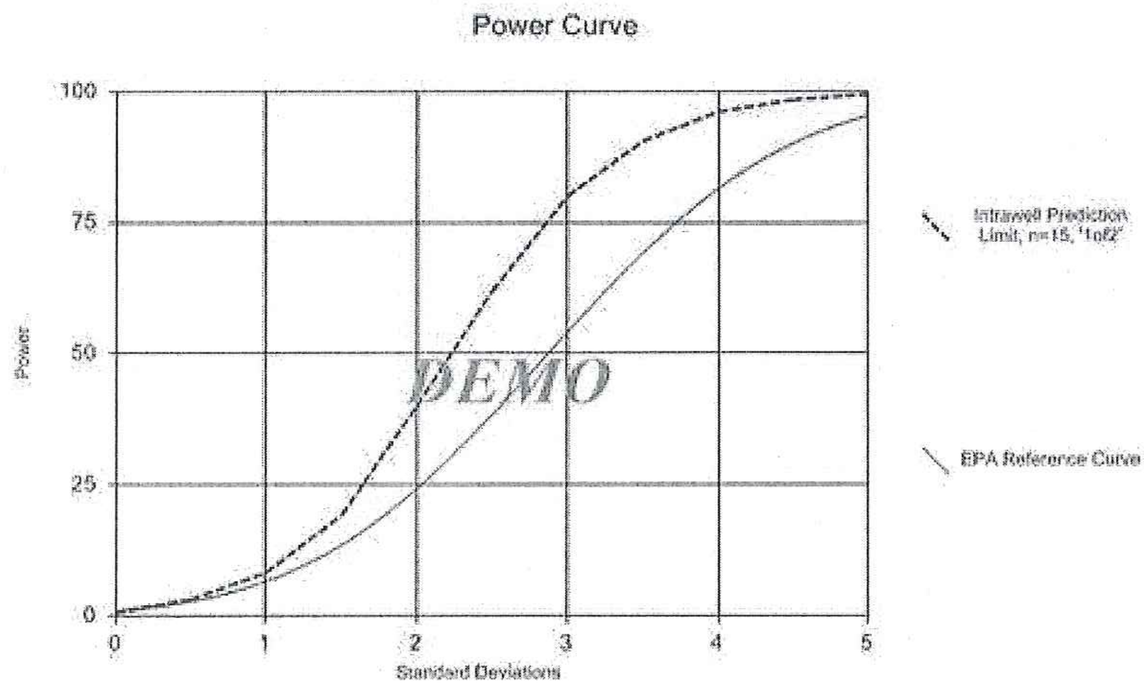
NOTICE: This e-mail and any files transmitted with it are the property of ARCADIS U.S., Inc. and its affiliates. All rights, including without limitation copyright, are reserved. The proprietary information contained in this e-mail message, and any files transmitted with it, is intended for the use of the recipient(s) named above. If the reader of this e-mail is not the intended recipient, you are hereby notified that you have received this e-mail in error and that any review, distribution or copying of this e-mail or any files transmitted with it is strictly prohibited. If you have received this e-mail in error, please notify the sender immediately and delete the original message and any files transmitted. The unauthorized use of this e-mail or any files transmitted with it is prohibited and disclaimed by ARCADIS U.S., Inc. and its affiliates. Nothing herein is intended to constitute the offering or performance of services where otherwise restricted by law.

Input Summary

Number of wells	6
Number of constituents	3
Number of baseline samples	15
Retesting schedule	1-of-2

This is the output from version 9.1.21

v.9.1.21 Not for commercial use. UG



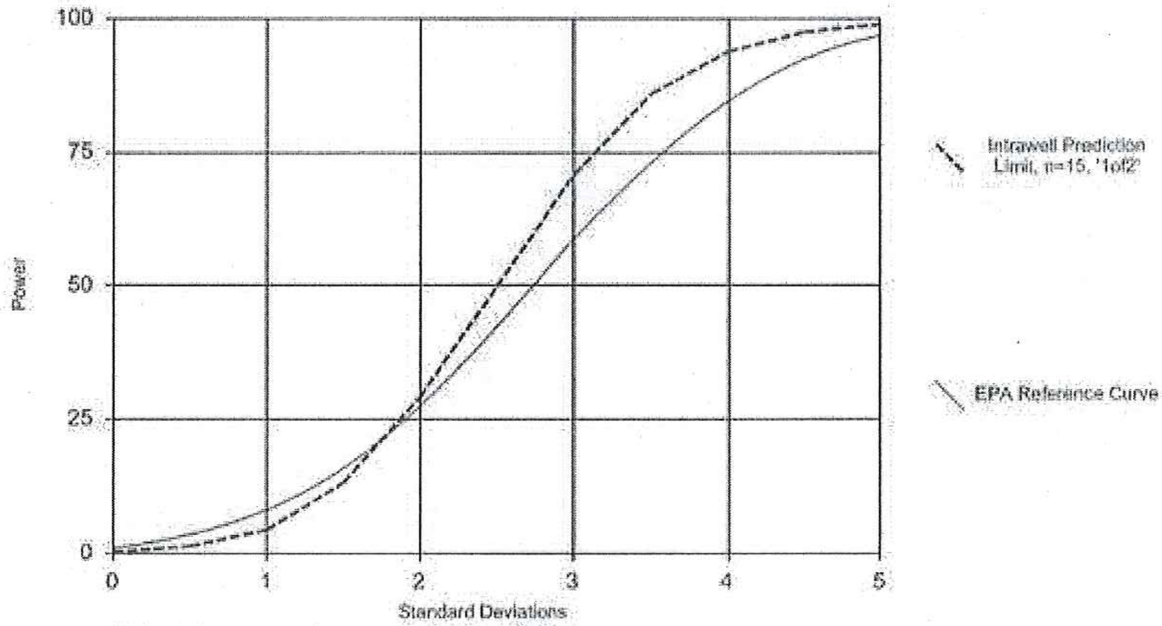
Kappa = 1.672, based on 6 compliance wells and 3 constituents.

Analysis Run 2/16/2011 11:30 AM

This is the output from version 9.2.10

v.9.2.10 For regulatory purposes only. UG

Power Curve



Kappa = 1.927, based on 6 compliance wells and 3 constituents.

Analysis Run 7/8/2011 1:14 PM

State of Oregon

Department of Environmental Quality Memorandum

Date: April 11, 2012

To: Paul Seidel

From: Fredrick Moore *Fredrick Moore*

Subject: Transmittal and Review Request of ARCADIS April 10, 2012, Memo Regarding Establishment of Upper Prediction Limits for a Groundwater Detection Monitoring Program at the Lockheed Martin The Dalles Facility ORD 052 221 023

Paul,

Please review the attached memorandum and EPA comments attached. In addition, please let me know if DEQ has the capability to construct power curves consistent with EPA guidance from the data found in the ARCADIS report. In lieu of constructing power curves, previously ARCADIS was able to run a sample demonstration using Sanitas software and constructed 2 informal power curves and emailed me the result. Please review the email and determine if the power curves are adequate.

The ARCADIS April 2012 memorandum is an update from their April 27, 2011, technical memorandum. Due to the delay of the permit renewal, they gathered another years worth of data and evaluated it with their determination of the upper prediction limits. ARCADIS also had EPA comments regarding the statistics (dated March 29, 2012) and addressed them also in the update.

The EPA comments to review are numbered 17, 18 and 19.

I am requesting that you compose a brief memorandum to me with your opinion on the ARCADIS update, the EPA comments and an evaluation of whether the power curves are sufficient. If possible, I would like this evaluation by April 20.

Many thanks for you looking into this. It is truly appreciated.

Attachments